Annex 7 : Request Letter of Monitoring

1. Background

The feasibility study on the Navigation of the Parnaiba River Basin has been commenced to clarify the possibilty on the navigation from January 1993. Especially, to grasp the performance of 3 test spur dikes construction as a countermeasure for ensuring the navigation channel , the monitoring for river bed movement has been done by JICA budget. To judge the performance , the long-term connected monitoring should be necessary . JICA Study Team requests the monitoring to Brasilian side .

2. Site condition after test spur dikes construction

Based on the site inspection and monitoring output , the site condition after the construction is below ;
(Dike arrangement and section location are shown in Interium Report (2))

Teresina :

(1) Sedimentation ,Dike TS-4 to the new bridge piers

The level of sedimentation is above El. 55.5, the height is about 1.6 m. Compared with the river bed condition of June 1993 ,sedimentation from TS-4 connects the piers caused 2 to 2.5 m increasing height (Picture 3).

(2) New divided channel by the sedimentation

By the sedimentation of the left side of Dike TS-3, the waterway with 100 m surface width upstream the dike and another waterway with 135 m width downstream the dike are formed (Picture 1). For the new waterway between TS-2 and TS-3 , the draft depth above 1 m with about 40 m width can be ensured at the datum water level El. 53.4 m.(Picture 2)

(3) Change of the water course existed during low water,1993

The low water course existed in 1993 could not be fixed. The interval of the Dike TS-2 to TS-4 were not efficient. The sedimentation downstream of TS-4 is predominant.
(Picture 3)

(4) Some piles loss in Dike TS-1 and TS-5

Local residents picked up some piles in the Dikes due to nasty smell of the drafts caught in the piles.

Uniao :

(1) The low water course existed in 1993 is still in the same side (Picture 4).

(2) The average river bed level approximately was degradated according to the cross section survey result and the bed level fluctuation . Especially, the minimum bed level of the section UL-4 to UL-7 is down judging from the drawings for Uniao in Annex submitted on September 1994 .

(3) The sand bar near the section UL-5 was disappered.

(4) Sedimentation of the left side of Dike US-3 to US-6 is remarkable. Sedimentation height is above 1 m behind the dike , compared with the bed level measured in June 1993. (Picture 5)

(5) Dike US-5 and US-6 is covered by the sand bed. The remark of Dike US-1,US-2 is not clear. Dike US-3, US-4 is still visual.

Buriti dos Lopes :

(1) Sedimentation behind Dike BS-8 , BS-9 is remarkble. According to the cross section BL-4, the height reaches El. 5.2 m , compared with the bed level El. 4.0 measured in June 1993.

(2) The bed level arround Maranhao side along section BL-1 , BL-2, BL-3 is deeper than the level measured in June 1993. It is considered that the tractive force at the time of flood scoured the river bed.

(3) Sedimentation downstream of Dike BS-7 is remarkble. The height reaches above 5 m. In the result, the water flow direction at around the end of Dike BS-7 is changed toward the center of the channel. (Picture 6,7)

3. Objective

Through the connected monitoring after July 1994 , the data processing and output for river bed movement should be conducted to check the stability of channel and changing of the bed level .

4. Survey section

The monitoring method is based on the cross-section survey attached in the Progress Report issued on March , 1994 . During high water season , the echo sounding survey will be more applicable.

The sections of the each site are listed below ;

Teresina

Section A and B will be surveyed for the new waterway divided by the sedimentation after Dike TS-3. Section C and D will be surveyed to check the changing of sedimentation downstream of Dike TS-4. Fig. 4.1 shows the section location for the survey .

: Section TL-1
: Section TL-2
: Section TL-3
: Section A
: Section B
: Section C
: Section D
: Section TL-7

Uniao

Survey sections are same of the previous survey as shown in Fig. 4.2.

: Section UL-1
: Section UL-2
: Section UL-3
: Section UL-4
: Section UL-5
: Section UL-6
: Section UL-7

Buriti dos Lopes

Section E and F will be surveyed to check the changing of the sedimentation downstream of BS-8 , BS-9 and confirm the thalweg. Fig 4.3 shows section location of the site .

: Section BL-1
: Section BL-2
: Section BL-3
: Section BL-4
: Section BL-5
: Section E
: Section F

5. Data processing

Based on the cross-section survey or the echo sounding survey , the data processing and monitorng outputs will be conducted as listed and shown of samples.

(1) Cross section drawing (Fig. 5.1)

(2) Point cordinates (Fig. 5.2)

(3) Fluctuation of river bed

Table 5.1
Time series changes of river bed

: Average bed level (Fig. 5.3)
: Minimum bed level (Fig. 5.4)

(4) Scouring/sedimentation condition of the section

Bed condition of scouring/sedimentation (Fig. 5.5)
Time series changes (Fig. 5.6)

Table 5.1 Fluctuation of River Bed for Uniao

Date	Line Number	Datum W.L. (EL.m)	Width (m)	Minimum Bed Level (EL.m)	Average B.L. (EL.m)	Preceding Width (m)	Preceding Average B.L. (EL.m)	Change (m)
5/2/94	UL1	42.30	228.54	40.10	41.34			
4/3/94			376.90	39.40	41.19	228.54	41.34	-0.15
17/3/94			357.85	40.10	41.21	376.90	41.19	0.02
26/3/94			265.22	40.30	41.26	357.85	41.21	0.05
28/4/94			341.39	40.00	40.85	265.22	41.26	-0.41
18/5/94			326.04	40.20	40.93	341.39	40.85	0.08
29/6/94			342.11	40.10	41.17	326.04	40.93	0.24
5/2/94	UL2	42.30	227.69	38.80	40.92			
3/4/94			148.36	39.10	41.10	227.69	40.92	0.18
17/3/94			234.77	39.10	40.98	148.36	41.10	-0.12
26/3/94			243.37	39.00	41.06	234.77	40.98	0.08
28/4/94			281.24	39.70	41.18	243.37	41.06	0.12
18/5/94			282.63	39.70	41.01	281.24	41.18	-0.17
29/6/94			264.30	40.10	41.09	282.63	41.01	0.08
5/2/94	UL3	42.30	244.03	38.60	40.72			
4/3/94			123.04	38.70	40.03	244.03	40.72	-0.69
17/3/94			193.05	38.90	40.96	123.04	40.03	0.93
26/3/94			148.48	39.00	40.62	193.05	40.96	-0.34
28/4/94			234.00	39.00	40.92	148.48	40.62	0.30
18/5/94			211.28	39.30	40.89	234.00	40.92	-0.03
29/6/94			194.57	38.90	40.73	211.28	40.89	-0.16
5/2/94	UL4	42.30	212.72	40.60	41.01			
4/3/94			160.66	40.30	41.05	212.72	41.01	0.04
18/3/94			154.39	40.20	41.10	160.66	41.05	0.05
26/3/94			164.99	39.60	40.43	154.39	41.10	-0.67
28/4/94			163.43	39.40	40.63	164.99	40.43	0.20
18/5/94			122.95	37.80	39.04	163.43	40.63	-1.59
30/6/94			305.71	38.60	41.28	122.95	39.04	2.24
6/2/94	UL5	42.30	115.02	40.90	41.80			
4/3/94			277.99	40.90	41.58	115.02	41.80	-0.22
17/3/94			297.29	41.00	41.37	277.99	41.58	-0.21
26/3/94			278.30	39.50	41.03	297.29	41.37	-0.34
28/4/94			133.76	38.60	39.83	278.30	41.03	-1.20
18/5/94			103.75	37.50	39.08	133.76	39.83	-0.75
30/6/94			117.23	37.30	39.92	103.75	39.08	0.84
6/2/94	UL6	42.30	227.86	40.30	41.40			
5/3/94			342.08	40.40	41.59	227.86	41.40	0.19
18/3/94			288.31	40.20	41.36	342.08	41.59	-0.23
26/3/94			288.22	40.50	41.32	288.31	41.36	-0.04
29/4/94			145.91	38.40	39.82	288.22	41.32	-1.50
18/5/94			97.28	37.10	38.73	145.91	39.82	-1.09
30/6/94			114.27	37.20	39.23	97.28	38.73	0.50

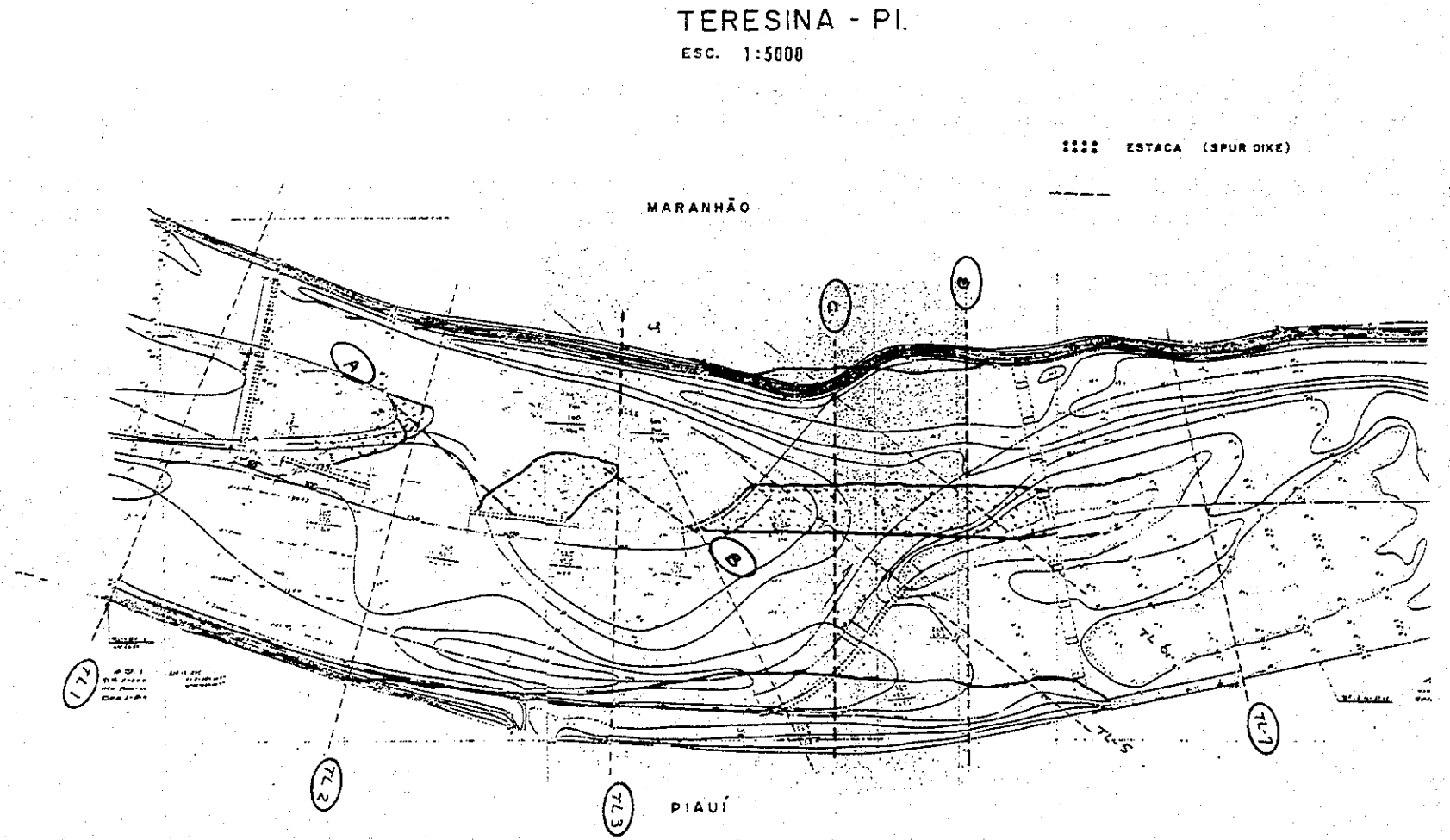

Fig. 4.1 Section Location for the Survey

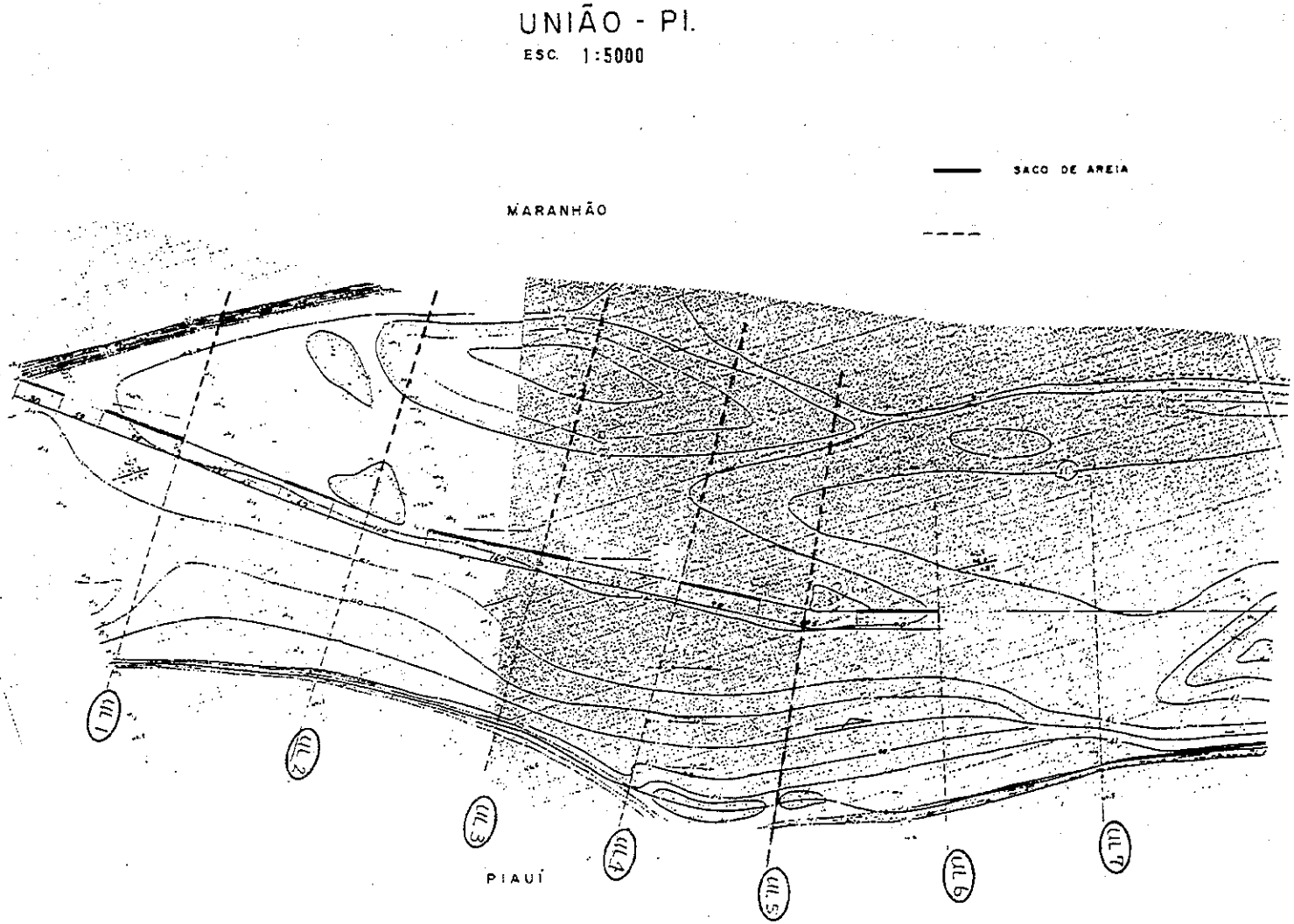

Fig. 4.2 Section Location for the Survey

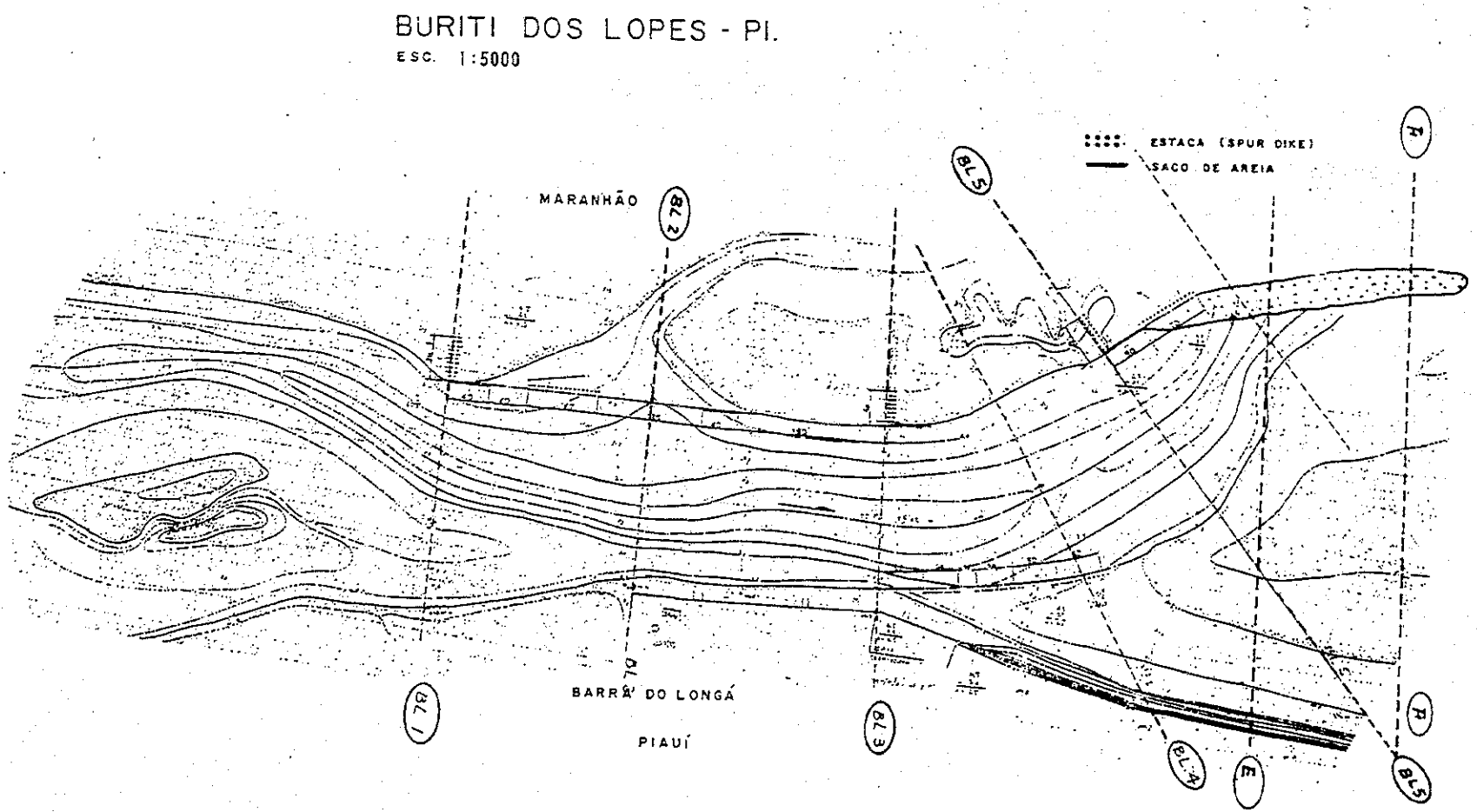

Fig. 4.3 Section Location for the Survey

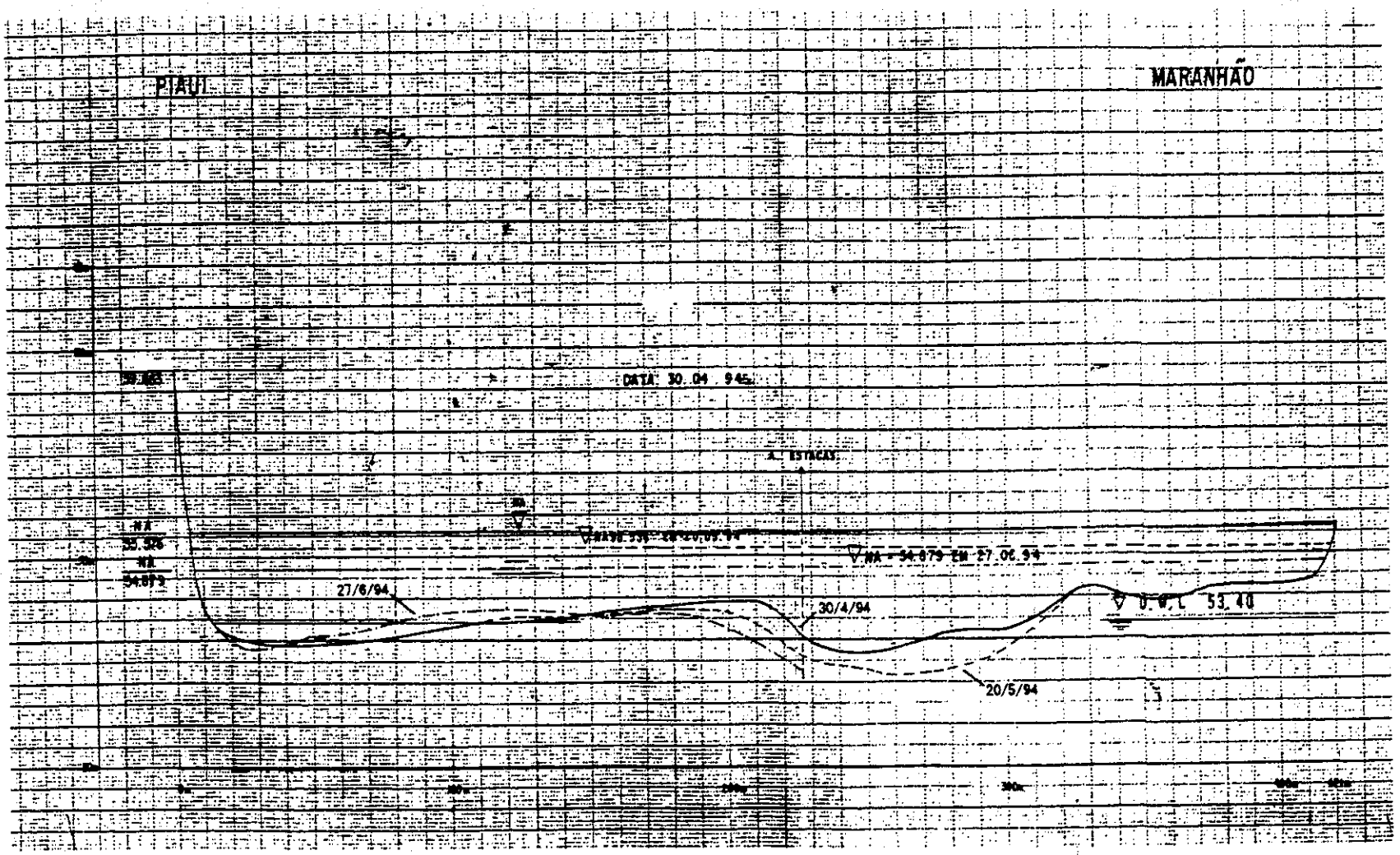

Fig. 5.1 Cross Section Drawing

Telesina

Line Number	Date	Spot number	Cordinates X	Y	Wetted Perimeter	Area	Wetted Perimeter	Area
TP1	3/2/94	E1	4.00	60.40				
		E2	12.50	56.60	1.29	0.13		
		E3	24.00	54.80	30.11	45.00		
		E4	54.00	52.20	32.00	86.40		
		E5	86.00	52.40	38.00	106.40		
		E6	124.00	52.00	30.00	87.00		
		E7	154.00	52.20	28.00	77.70		
		E8	182.00	52.25	13.02	31.53		
		E9	195.00	52.90	12.13	14.40		
		E10	207.00	54.70	6.41	24.07		
		E11	223.00	55.45				
		E12	264.00	55.80				
		E13	291.00	55.90	16.32	4.49		
		E14	334.00	54.45	36.01	31.50		
		E15	370.00	53.80	34.00	44.20		
		E16	404.00	53.60	16.03	14.00		
		E17	420.00	54.65	3.14	64.67		
		E18	430.00	55.77				
		E19	438.00	58.90	296.47	631.48		
	Width		190.7	105.44	296.1			
	Hm		1.09					
	Average Bed Level		52.31					

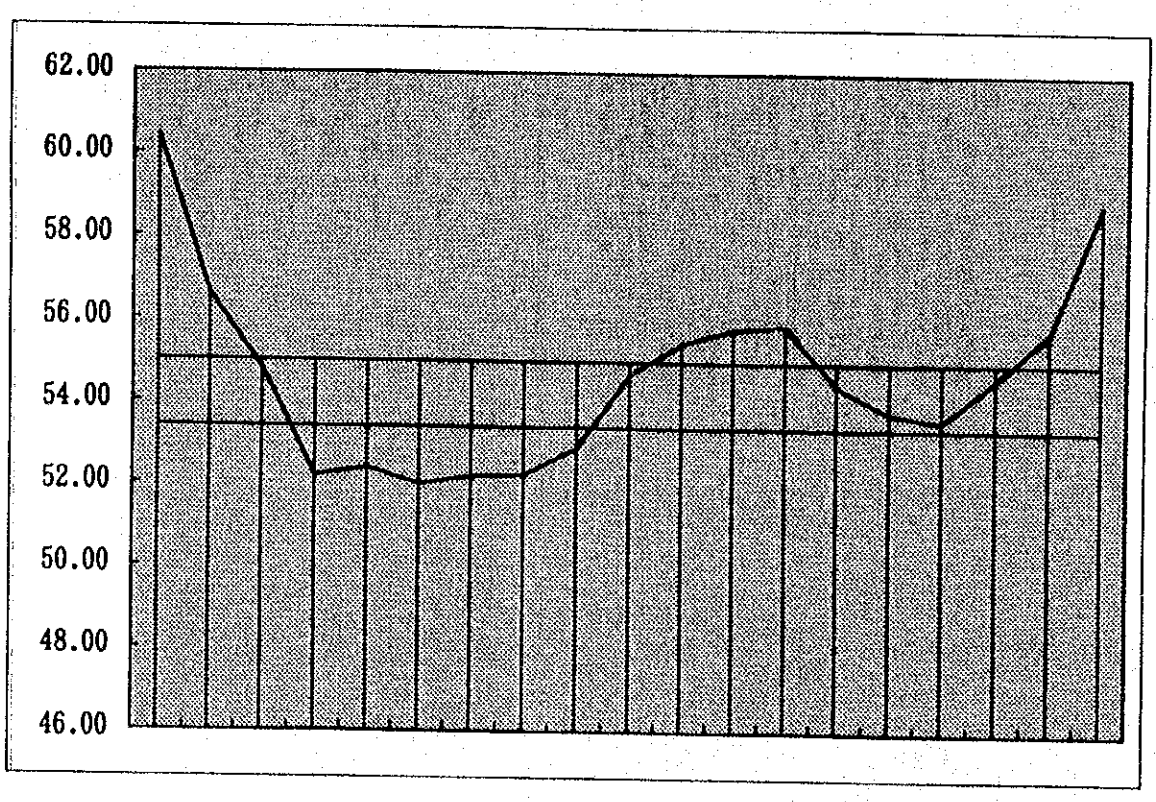

Fig. 5.2 Section Point Cordinates

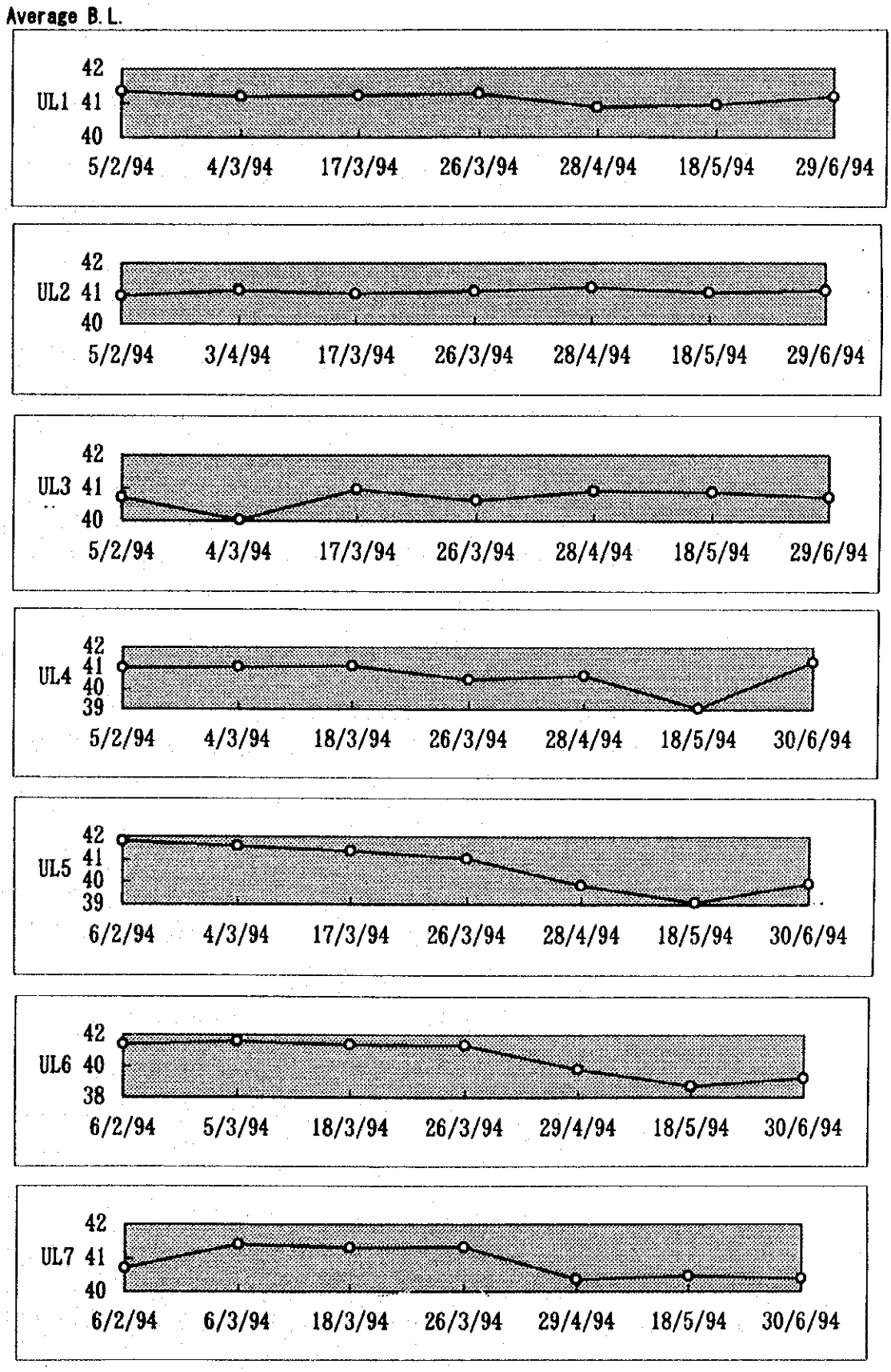

Fig. 5.3 **Time Series Changes of Bed Level For Uniao**

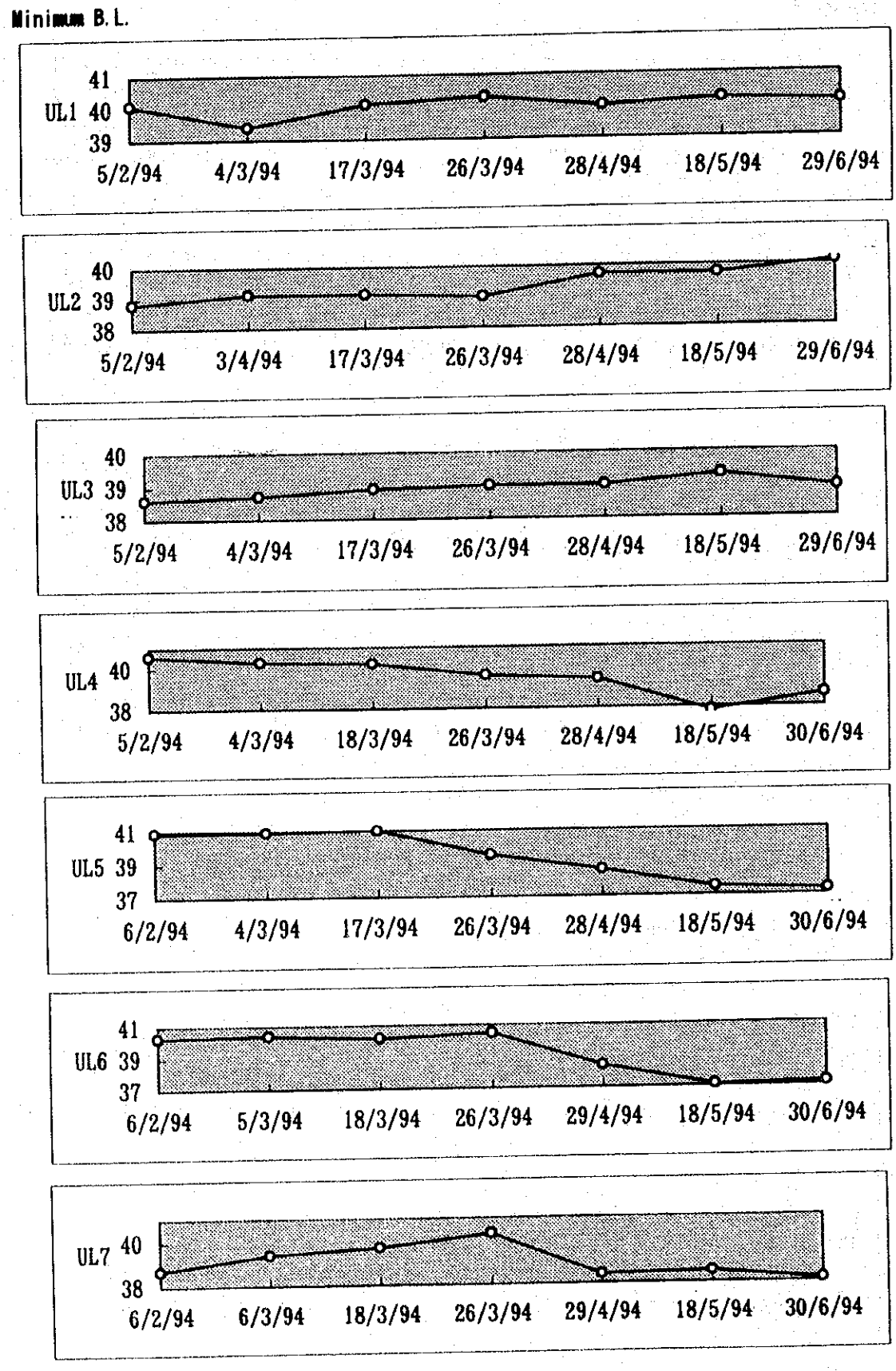

Fig. 5.4 **Time Series Changes of Bed Level For Uniao**

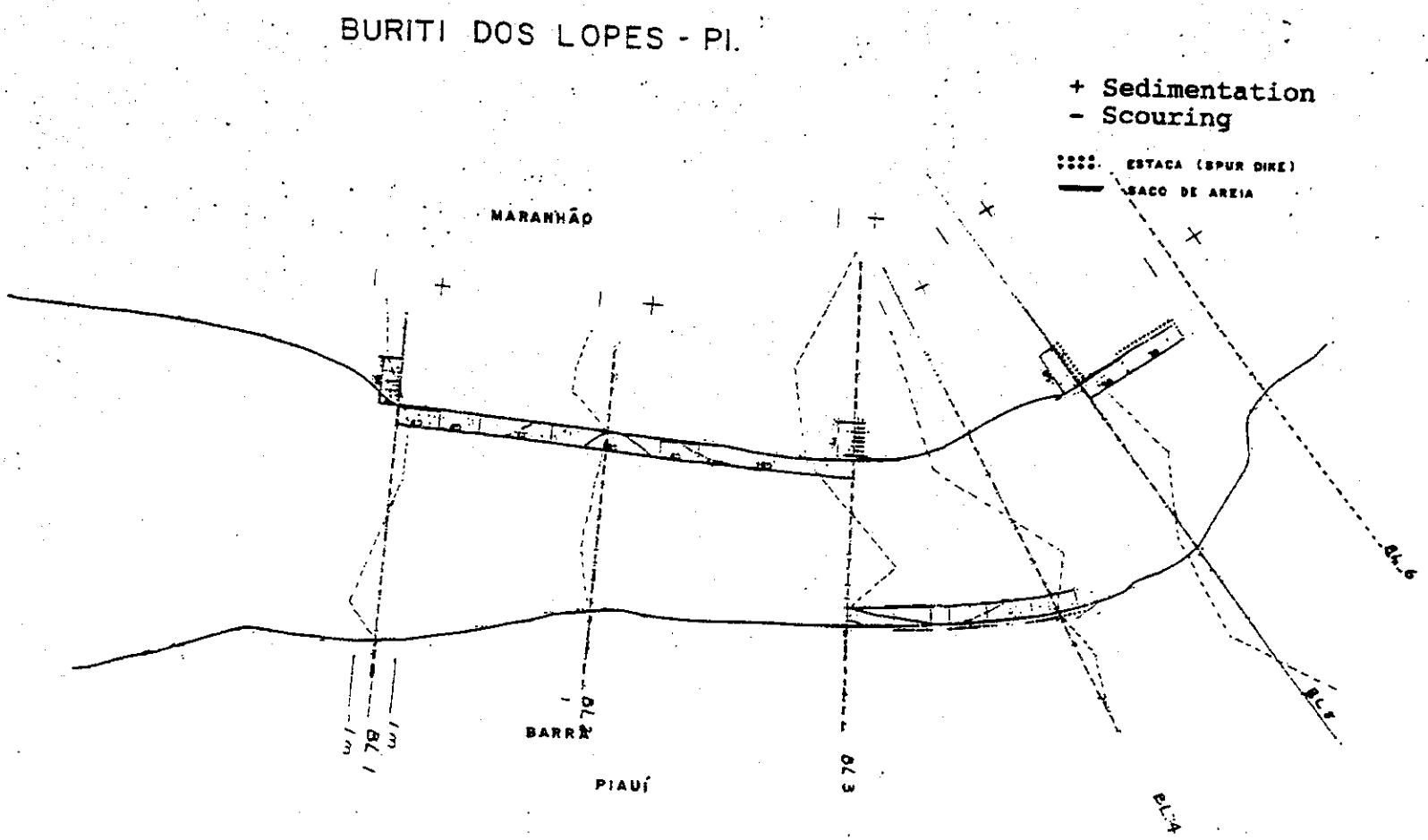

Fig. 5.5 Bed Condition of Scouring / Sedimentation for Buriti dos Lopes

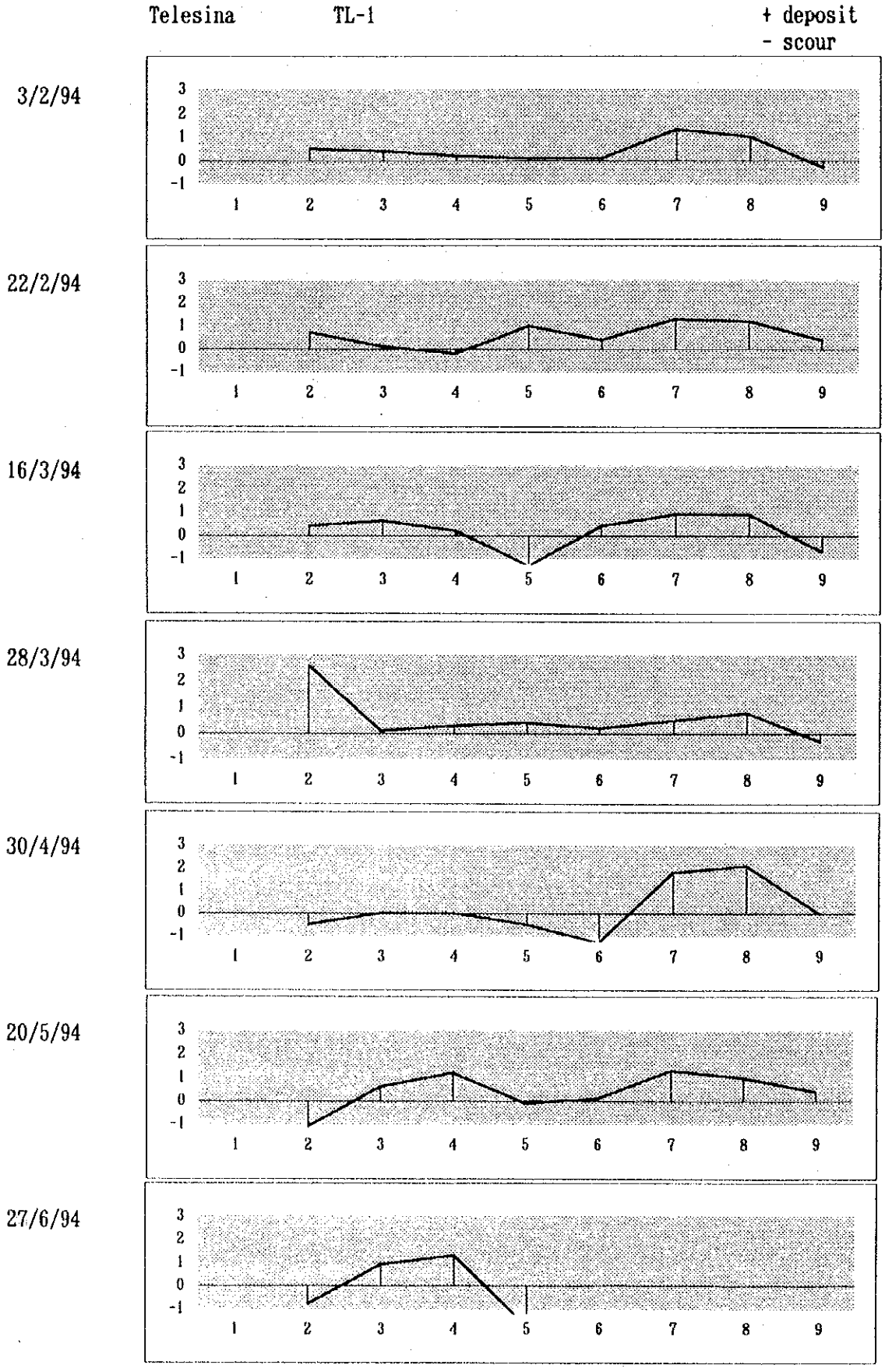

Fig. 5.6 Time series changes

Annex 8 : Sand Bar Inventory

Table of Contents

1. SandD Bar Inventory Study

1.1 Objective

The objective for preparing the sand bar inventory at the main Parnaiba stream is to obtain fundamental information on the following points.

(1) To determine the navigation channel plan for the river Parnaiba,
(2) To determine the construction plan of the signs for the channel and the information system of the channel condition, and
(3) To select the construction site for three (3) spur dikes.

2. Overview of the Parnaiba Basin

2.1 Overview of the River

(1) The river Rio Parnaiba

The main stream of the river Rio Parnaiba originates in the highland located at 45 degrees west longitude and 10 degrees south latitude. The river runs through the lake Esperanca (Esperanca dam) located at the center of the valley, merges with many branches, and finally reaches the Atlantic ocean. Overall length of the river is 1,344 kilometers.

The river consists of main branches of Rio Balsas, Rio Urucui Preto, Rio Gurgueia, Rio Caninde, Rio Poti, and Rio Longa.

The transverse gradient of the river is approximately 1/6,000 for the downstream portion of the river Rio Parnaiba (from Guadalupe to the estuary), and the same for the upstream portion (from Santa Filomena to Urucui) is 1/3,700, which indicates that the gradient is much steeper for the upstream portion. The overall length of the river Rio Balsas between Urucui and Balsas is approximately 120 kilometers less than that between Urucui and Santa Filomena, however, the gradient is much steeper, as steep as 1/2,500, since the altitude of Balsas is about the same as that of Santa Filomena.

The flood season of the river Rio Parnaiba is from October to May, and the dry season is from June to September. Table 2.1 shows the maximum and minimum water levels for the rivers Rio Parnaiba and Rio Balsas.

(2) The river Rio Balsas

The river Rio Balsas has the overall length of 525 kilometers and runs through the state of Maranhao, which merges into the river Rio Parnaiba at Urucui. The gradient of the river bed is steep and it is meandering.

The water levels at the river Rio Balsas varies throughout the season just like the river Rio Parnaiba, however, the water level is at its peak in the period of October to April. The water level is the lowest from June to September.

The portion of the channel that allows navigation of the vessels at the river Rio Balsas is between the cities of Balsas and Urucui, and its overall length is approximately 255 kilometers. The river bed gradient is approximately 82 cm per kilometer.

2.2 Geology

The valley is an extremely stable plateau which was accumulated in the period from the end of the Paleozoic era to the Mesozoic era, and consists of alternately accumulated layers of congromerate, sandstone, slate, and dirt bed which upheaved in the Tertiary period. On the upstream side of the river, the original profile of the soil is well preserved which accounts approximately 60% of the entire valley, and the soil profile can be observed in which the rocks cut into the vast table shaped plateau.

On the downstream side of the merging point with the Rio Caninde, the table shaped plateau begins to diminish while being completely surrounded by the valleys or loses its flat portion and forming small conical mountains or hills.

On the downstream side that begins from the area of Teresina, the original profile of the river is not maintained any more. It has a flat profile with the diluvium plateau outside the flood plain including the naturally formed bank along the river Rio Parnaiba.

The river is split into two channels at the estuary, and the area surrounded by the two channels is covered with mangrove. The coastal area consists of dunes.

Recently, farming fields have been developed at the flat portions of the table shaped plateau on the upstream side of the river, and crops such as rice, soy bean, etc. are being cultivated. The area is the savanna which is called Cerrado and no vegetation can be seen during the dry season.

There is a green belt along the narrow valley except for the cliff areas.

The middle course of the river has hilly profile with cultivated table shaped plateau. The flood plane lies along the channel at the downstream course of the river.

2.3 Water Level and Discharge

Observation of the water level at the river Rio Parnaiba is carried out by SHESF. There are nine water level observation stations, and discharge is calculated at seven stations using individually developed the rating-curves. With the survey drawings, datum altitudes of these stations were measured using the global positioning system (GPS). Further, two more measurement stations were newly constructed at Parnaiba and Amarante.

Table 2.2 lists the datum altitudes of the stations. The maximum water levels, and minimum water level at these stations are shown in Table 2.1.

Table 2.1 Extream Water Level of the Basin

River	Station Name	Year	Rainy Season	Dry Season	High W.L. (m)	Low W.L. (m)
Parnaiba	Volta do machado	1979	Jan. to May	July to Oct.	4.96	1.42
		1983	Feb. to April	July to Oct.	4.14	1.46
Parnaiba	Alto Parnaiba	1973	Dec. to April	June to Sep.	5.83	3.39
		1983	Dec. to March	July to Oct.	6.30	3.50
Parnaiba	Ribeiro Goncalves	1973	Dec. to April	June to Sep.	4.28	2.46
		1983	Dec. to March	July to Oct.	5.38	2.67
Parnaiba	Paracati Fazenda	1974	Jan. to May	July to Oct.	4.42	1.92
		1983	Jan. to April	July to Nov.	4.90	1.93
Parnaiba	Floriano	1982	Jan. to April	July to Nov.	6.82	0.50
Parnaiba	Teresina	1964	Jan. to April	July to Sep.	4.70	0.50
		1983	Dec. to April	Aug. to Oct.	5.98	2.19
Balsas	Sao Felix	1974	Jan. to April	July to Oct.	6.82	1.30
		1983	Dec. to April	July to Oct.	4.18	1.09
Balsas	Balsas	1974	Dec. to April	July to Sep.	3.90	2.34
		1983	Dec. to April	July to Sep.	5.10	2.48

Table 2.2 Zero Gauging Level for 11 Stations

Station Name	Survey Date	Zero Gauging Level (E.L. m)	Water Level in Altitude (m)
1. Parnaiba	'93. 1.22	0.2	
2. Luzilandia	'93. 1.22	13.6	16.0
3. Uniao	'93. 1.16	40.1	43.4
4. Teresina	'93. 1.13	52.4	55.8
5. Fazendan Veneza	'93. 1/14	62.7	67.5
6. Amarante	'93. 1.28	86.0	86.4
7. Floriano	'93. 1.29	97.1	100.9
8. Guadalupe	'93. 2.1	122.1	113.5
9. Urucui	'93. 2.2	157.1	159.4
10. Ribeiro Golncaues	'93. 2.3	186.7	189.7
11. Santa Filomena	'93. 2.5	263.8	267.6

Source: Consultants Survey

3. Sand Bar Inventory

3.1 Procedure

(1) Basic data

The following data consist of the basic data to prepare the inventory.

Aerophotography mosaic (blue prints)
(Scale = 1:10,000)
"Projet de Desenvolivimento do Sistems Fundiaro Nacional Projet Nordestra (by INTERPI)"

Aerophotography mosaic by JICA
(Scale = 1:20,000)

(2) Data input equipment

Data related to the sand bar are input using the following equipment.

Personal computer: Toshiba J3100
Digitizer: TCC

(3) Data processing

Data input via the digitizer are processed using the program which is newly developed this time to prepare the summary table and database file for respective sand bars using the software " Data Base 3 ".

(4) Contents of information

Information contained in the inventory summary table, and database file are to be input to the fullest extent as possible based on the information and aerophotography mosaic drawings.

1) Those that are related to the drawings

Photograph numbers
Scales
Shooting dates
Locations of the base mosaic

2) Those that are related to the sand banks

Bar numbers
Locations of the center
River widths
Bar widths
Bar lengths

Bar areas
Bank off lengths
Vegetation
Channel patterns
Bar configurations
Spot elevations

The channel patterns in case of the natural rivers can be classified into the following three categories.

a) Straight channel,
b) Braided channel, and
c) Sinuous or meandering channel.

a) Characteristics of the straight channel

In case of the natural rivers, it is possible to have a straight channel for a short distance. However, it is rather rare to have a straight channel for the distance of 10 times greater than the river width. Even when the channel is straight, the valley line (thalweg) that connects the deepest points of the river bed is meandering.

b) Characteristics of the braided channel

The braided channel represents a channel that is divided into multiple channels by the sand banks or islands when the water level is low. Consequently, these divided channels merge from one to another to form a braided pattern.

c) Characteristics of the sinuous or meandering channel

A deep pool is created at the concave portion of the bend of the channel, and the sand is accumulated on the convex portion on the opposite bank to form a point bar. Accordingly, the cross sectional area will have an asymmetrical profile.

The sand bars are classified into the following key categories.

a) Point bar,
b) Staggered sand bar,
c) Multiple sand bar, and
d) The sand bar that changes from the phase b) to c)

3.2 Inventories

The types of the inventory to be prepared are the primary inventory and the secondary inventory.

The primary inventory is to be prepared based on the mosaic blue prints obtained by the "Projet de desenvoluimento do sistema Fundiaro, nacional Projet" which was carried out by INTERPI in 1983. The survey area determined by the mosaic blue prints is between Luzilandia and Parmeirais.

The secondary inventory is to be prepared based on the mosaic obtained by the aerophotography taken in June, 1993 during the survey. The area determined by the aerophotograph is between Parnaiba and Nova Guadalupe.

(1) Primary Inventory

The overall number of the sand bars identified by the primary inventory is 83. Among those, the largest sand bar is Ilha de Sao Cristovao of which area is 1,900,000 m2.

Table 3.1 shows the summary inventory table .

(2) Secondary Inventory

Continuing the Primary inventory based on the mosaic prepared by INTERPI in 1983, the work for the sand bar identification was done using the mosaic aerophotographs obtained by the end of August 1993. The aerophotographs between Parnaiba and Nova Guadalupe were prepared by JICA Team.

The Secondary inventory are listed in Table 3.2. The overall number of sand bars is 308. The sand bar information of the inventory is composed of photo number , bar number ,location , river width , bank off length ,and the dimension of the bar. The location is based on the Brasilian coordinates illustrated in the mosaic.

In this table , 6 sand bars exists with the area above 2,000,000 m2 and form the islands. These bars are downstream of Luzilandia . The largest with the area of 4,120,000 m2 is located in East 807,996 and 9,619,586 of cordinates. Ilha de Sao Cristovao has area of 2,480,000 m2 in Year 1993 .

3.3 Data Base

The sand bar data base for the Primary and Secondary inventories is prepared by using the software of " Data Base 3 ". The form of the sand bar data base listed in Table 3.2 is composed of inventory and additional information such as location map, picture copy, vegitation, channel configuration, bar configuration etc.

For the data base form of the Primary inventory , the picture copy of the year 1993 mosaic are attached , in the addition of the 1983 mosaic. All data base forms are compiled in the Progress Report issued on March 1994.

Table 3.1 (1) Sand Bars Summary Inventory (Primary)

NO	Photograph Number	Bar Number	Location Longitude	Location Latitude	River Width	Bank off Length Right	Bank off Length Left	Bar Width	Bar Length	Bar Area(m2)
1	074392	01	42.5243	4.2761	746.2	44.1	345.9	356.2	1935.4	481736
2	074392	02	42.5240	4.2799	550.1	234.1	131.7	184.3	404.7	42382
3	074392	03	42.5156	4.2837	291.5	179.0	0.2	112.3	1366.0	36816
4	074392	04	42.5131	4.2842	382.7	157.3	117.5	107.9	494.7	36816
5	074393	01	42.5092	4.2903	401.5	84.0	223.6	153.8	827.7	75699
6	081302	01	42.5254	4.3206	436.5	269.9	98.6	67.9	139.4	4749
7	081302	02	42.5253	4.3216	433.3	200.3	95.0	138.0	388.3	32895
8	081302	03	42.5141	4.3027	1424.0	383.6	94.3	946.0	2721.6	1805305
9	081312	01	42.5238	4.3440	908.2	628.1	40.4	239.7	1422.6	216440
10	081312	02	42.5246	4.3474	755.0	435.1	58.0	262.0	681.2	105899
11	081312	03	42.5216	4.3434	678.0	289.6	296.7	91.7	248.2	11876
12	081312	04	42.5220	4.3438	787.0	351.6	364.6	70.8	203.7	9468
13	081312	05	42.5215	4.3458	908.2	187.6	663.6	57.1	164.9	5916
14	081312	06	42.5264	4.3560	757.3	42.5	399.6	315.2	2352.8	460348
15	081312	07	42.5304	4.3587	691.7	392.3	196.4	103.1	652.4	39207
16	081321	01	42.5406	4.3738	706.7	277.4	74.9	354.8	1066.4	215427
17	081321	02	42.5419	4.3780	459.9	179.9	191.9	88.1	296.9	15561
18	081322	01	42.5374	4.3700	729.5	182.5	305.3	241.7	1381.7	187322
19	081330	01	42.6017	4.3818	1022.9	178.1	184.4	660.5	2645.2	1188987
20	081331	01	42.5499	4.3915	404.5	59.6	175.5	169.4	800.4	69960
21	081331	02	42.5547	4.3941	536.9	120.7	112.0	304.2	735.8	148162
22	081331	03	42.5574	4.3959	544.6	198.0	143.8	202.9	833.2	104492
23	081341	01	42.5536	4.4457	323.9	201.7	14.2	107.9	686.6	48030
24	081351	01	42.5662	4.4572	385.3	0.4	280.2	105.4	850.5	61402
25	081351	02	42.5695	4.4713	688.2	105.5	203.4	379.2	1413.2	305334
26	081351	03	42.5684	4.4751	640.3	154.8	133.9	351.6	1034.9	218282
27	081351	04	42.5678	4.4781	681.7	206.8	203.8	271.2	514.9	70491
28	081361	01	42.5658	4.4818	424.0	184.9	87.7	151.4	576.7	54476
29	081361	02	42.5608	4.4867	321.2	97.6	147.4	76.3	213.9	10489
30	081361	03	42.5472	4.4982	309.1	229.6	0.0	79.5	440.1	23577
31	081362	01	42.5373	4.5084	372.9	191.4	140.1	41.6	172.2	4951
32	081372	01	42.5356	4.5163	374.5	49.4	217.1	114.0	382.4	27800
33	081372	02	42.5363	4.5310	522.7	156.8	68.4	297.4	967.9	186835
34	081372	03	42.5350	4.5331	525.0	140.7	315.4	69.0	362.1	14109
35	081372	04	42.5321	4.5386	476.3	0.4	380.2	96.3	450.1	25528
36	081382	01	42.5319	4.5407	466.6	77.8	183.1	205.7	912.3	102275
37	081382	02	42.5288	4.5494	1542.7	239.8	72.2	1230.7	2775.4	1897575
38	081382	03	42.5246	4.5490	479.0	219.1	148.9	111.1	477.1	36900
39	081392	01	42.5145	4.9720	333.8	67.4	139.9	126.5	265.0	21519
40	081392	02	42.5154	4.9765	504.7	48.1	332.0	124.7	411.8	25827
41	081392	03	42.5156	4.9842	586.5	34.3	366.0	186.3	1577.2	166925
42	081392	04	42.5155	4.9784	570.3	16.6	456.0	97.7	349.0	24442
43	081392	05	42.5170	4.9800	572.3	270.8	241.0	60.5	105.0	3804
44	081392	06	42.5151	4.9885	582.1	0.0	152.1	430.0	1276.5	271272
45	088602	01	42.5113	5.0031	553.9	76.9	66.2	410.9	1237.1	313046
46	088603	01	42.5092	5.0089	446.6	336.3	0.2	110.2	726.6	48999
47	088603	02	42.5069	5.0119	479.7	85.9	169.2	224.5	840.4	114665
48	088603	03	42.5045	5.0159	569.6	0.0	448.5	121.2	772.4	62227
49	088603	04	42.5055	5.0193	623.4	196.6	116.2	310.6	457.9	68892
50	088603	05	42.5052	5.0199	634.5	171.0	50.8	412.6	423.4	56071
51	088603	06	42.5047	5.0234	525.6	0.8	185.8	339.8	1729.1	271832
52	088613	01	42.5040	5.0347	316.7	0.0	130.6	186.2	459.1	39753
53	088613	02	42.5038	5.0377	330.9	75.0	114.9	141.0	782.2	58065

Table 3.1 (2) Sand Bars Summary Inventory (Primary)

NO	Photograph Number	Bar Number	Location Longitude	Location Latitude	River Width	Bank off Length Right	Bank off Length Left	Bar Width	Bar Length	Bar Area(㎡)
54	088613	03	42.5027	5.0430	628.9	118.0	0.6	511.5	942.8	250083
55	088613	04	42.5009	5.0448	592.8	128.4	151.2	313.1	575.7	74371
56	088613	05	42.4995	5.0462	503.8	43.8	133.3	326.8	575.2	92966
57	088613	06	42.4911	5.0563	358.6	0.2	181.8	176.7	635.0	62002
58	088613	07	42.4912	5.0586	436.6	298.2	76.5	61.9	158.9	5983
59	088613	08	42.4903	5.0592	434.7	169.9	218.5	46.4	123.7	2950
60	088623	01	42.4898	5.0616	433.9	98.5	162.9	172.5	554.1	70032
61	088623	02	42.4902	5.0672	412.2	149.6	43.9	218.7	749.6	100738
62	088623	03	42.4897	5.0700	369.3	121.9	162.9	84.5	241.2	10417
63	088623	04	42.4881	5.0769	256.8	28.2	172.7	55.9	475.7	25603
64	088623	05	42.4874	5.0825	351.9	164.5	69.6	117.8	305.6	24865
65	088633	01	42.4815	5.0951	359.4	53.5	146.9	158.9	410.0	36425
66	088634	01	42.4794	5.1136	286.4	162.4	12.9	111.3	497.8	37874
67	088653	01	42.4938	5.1552	567.4	139.4	240.4	187.6	846.2	99955
68	088653	02	42.4867	5.1691	510.9	3.7	292.9	214.4	1181.1	182312
69	088653	03	42.4865	5.1739	484.2	47.9	160.6	275.8	1032.0	158901
70	088681	01	42.5490	5.2424	353.1	102.5	96.2	154.5	361.2	38220
71	088690	01	42.7671	5.1146	223.5	151.5	0.6	71.5	294.5	13614
72	088690	02	42.8095	5.2223	214.1	19.7	135.4	59.1	174.7	5745
73	096219	01	43.0209	5.3545	524.3	173.4	43.3	307.7	1207.6	212344
74	096228	01	43.0566	5.3690	382.2	18.5	181.5	182.2	397.4	39681
75	096228	02	43.0577	5.3694	443.7	270.2	71.4	102.1	397.8	24123
76	096228	03	43.0567	5.3707	458.5	1.1	259.9	198.7	1370.7	166667
77	096228	04	43.0583	5.3795	255.7	101.9	0.2	153.8	735.6	73275
78	096228	05	43.0519	5.3803	512.8	103.4	124.3	285.2	1160.7	176227
79	096257	01	43.0614	4.4573	438.0	283.2	82.1	72.8	303.0	15805
80	096278	01	43.0528	5.5317	528.4	205.2	144.6	178.6	590.3	59824
81	104030	01	42.6202	5.9957	287.5	120.4	91.1	76.1	337.9	13655
82	104030	02	42.6099	5.9989	296.1	87.4	109.6	99.1	210.2	11282
83	104030	03	42.6010	6.0002	298.8	73.7	186.9	38.2	147.8	4012

Table 3.2 (1) Sand Bars Summary Inventory (Secondary)

No.	Photo Number	Bar No.	Location		River Width	Bank off Length		Bar		
			X	Y		Right	Left	Width	Length	Area(m²)
1	009	01	188640	9670810	954.1	33.2	333.1	587.7	2792.0	945764
2	010	01	186600	9668158	844.0	342.4	0.1	501.5	3780.2	1076231
3	011	01	184698	9663890	1191.8	0.1	417.6	774.2	3734.5	1794189
4	011	02	183358	9663070	863.3	0.2	422.2	441.3	2701.2	803111
5	012	01	181540	9662140	1023.1	259.8	0.0	763.3	3811.1	1700830
6	013	01	180485	9660320	512.2	148.6	328.8	34.8	157.1	2694
7	013	02	180092	9659676	551.0	71.6	249.4	230.0	947.9	136739
8	013	03	179425	9658901	527.9	163.9	157.5	206.5	996.7	117270
9	014	01	178210	9657379	420.5	177.6	142.8	100.2	413.9	26480
10	014	02	177475	9656393	351.0	50.3	221.2	79.5	327.1	15059
11	014	03	176582	9656201	350.7	85.9	151.3	113.5	511.8	34792
12	015	01	175414	9655858	286.6	7.8	160.8	118.0	942.5	71931
13	015	02	174709	9655250	397.9	199.7	44.6	153.6	1988.6	162843
14	015	03	175066	9654125	352.6	11.5	262.3	78.8	344.8	16041
15	015	04	175152	9653604	407.0	0.1	197.7	209.2	928.6	108898
16	016	01	174874	9653128	766.5	296.0	283.1	187.4	420.8	46952
17	016	02	174692	9652256	786.0	35.7	127.4	623.0	1494.9	447033
18	016	03	174659	9653085	790.9	552.4	149.7	88.8	348.2	18677
19	016	04	174518	9652951	785.1	649.0	54.7	81.5	166.1	9336
20	016	05	174135	9652161	870.1	669.9	0.0	200.2	717.7	58971
21	016	06	173207	9650478	1423.7	172.7	49.9	1201.1	2470.2	1407599
22	016	07	174297	9651610	939.5	179.4	587.0	173.2	498.4	63856
23	016	08	173513	9651349	1000.1	815.6	0.0	184.4	847.9	93003
24	016	09	174138	9650724	1061.8	80.4	892.3	89.1	279.7	11836
25	016	10	174010	9650370	1296.7	19.9	1246.8	29.9	219.4	4386
26	017	01	173374	9649522	417.2	116.7	213.0	87.4	326.1	17556
27	017	02	173557	9647941	238.8	130.5	0.3	108.6	615.1	32723
28	017	03	173273	9647271	479.9	87.5	191.9	200.6	475.6	52635
29	017	04	172917	9647257	467.9	0.2	330.9	137.0	404.0	26011
30	017	05	172516	9647755	575.7	92.6	76.0	407.1	822.4	152318
31	017	06	172387	9648049	645.4	453.9	172.5	19.0	55.3	695
32	017	07	172299	9648329	805.4	591.0	123.5	90.8	276.9	17629
33	018	01	171652	9648178	845.0	62.1	354.5	428.4	1354.5	382944
34	018	02	170355	9647967	673.6	174.5	112.8	386.4	543.2	137112
35	019	01	170000	9647632	1024.2	458.4	389.4	176.5	739.2	73365
36	019	02	169703	9646032	1059.8	249.7	260.5	549.6	3705.7	1100908
37	019	03	169523	9646674	1130.7	400.6	54.8	675.4	1741.8	708274
38	019	04	169810	9647317	1138.4	561.5	480.4	96.5	478.6	28050
39	019	05	170088	9646650	1157.6	143.2	940.3	74.0	309.6	12775
40	019	06	169802	9644738	1025.0	0.0	611.3	413.8	3350.9	785378
41	020	01	833858	9642144	808.7	225.7	1.3	584.3	1869.5	618073
42	021	01	833412	9641334	732.1	0.1	283.7	448.5	1791.0	357067
43	021	02	832192	9640898	449.7	299.6	14.3	135.8	649.5	55524
44	021	03	831071	9640299	708.8	152.6	20.3	535.9	2377.0	879274

Table 3.2 (2) Sand Bars Summary Inventory (Secondary)

No.	Photo Number	Bar No.	Location		River Width	Bank off Length		Bar		
			X	Y		Right	Left	Width	Length	Area(m²)
45	022	01	829340	9640175	885.4	0.0	141.9	743.5	4167.3	2133100
46	023	01	825350	9639414	1243.5	288.5	0.1	955.1	3038.6	1584835
47	023	02	825190	9638690	1190.3	45.1	0.1	1145.2	420.5	22374
48	023	03	824037	9639167	755.5	210.5	79.3	465.8	1293.8	389931
49	024	01	823252	9639094	562.2	168.9	94.2	299.1	1078.1	221353
50	025	01	820548	9638924	603.9	110.0	100.9	393.0	1554.2	315669
51	025	02	820263	9638635	587.1	72.1	417.3	97.7	474.6	28807
52	025	03	819344	9637981	288.4	0.4	137.6	150.8	1249.7	120977
53	026	01	818820	9636556	871.1	147.0	188.3	535.8	1822.5	825573
54	027	01	822384	9635404	222.8	113.6	0.0	109.2	900.5	48783
55	028	01	822775	9633970	474.3	82.2	153.4	238.7	1283.4	209517
56	028	02	821146	9633386	451.5	194.7	8.3	248.5	1640.5	207674
57	029	01	819530	9632414	887.5	0.0	136.6	751.0	1816.5	875924
58	029	02	819365	9630467	943.9	197.4	0.0	746.5	2314.2	1085732
59	030	01	818654	9629288	344.9	105.4	123.8	115.8	592.6	39564
60	030	02	817322	9628201	694.0	0.2	182.7	511.4	2240.8	753850
61	031	01	817110	9626690	444.5	103.8	249.8	90.9	423.4	21530
62	031	02	814817	9624413	516.7	124.3	0.0	392.4	4203.5	1191927
63	031	03	816752	9625334	613.5	151.0	394.5	68.0	277.9	9737
64	032	01	812912	9624448	268.7	205.8	0.2	63.1	390.0	10586
65	033	01	811950	9624124	474.9	10.2	224.7	240.0	1230.8	191149
66	033	02	811573	9624190	600.6	476.2	66.9	57.5	146.8	4234
67	033	03	811124	9623307	1149.4	185.1	22.0	942.3	1870.9	1111598
68	034	01	811004	9621802	381.0	156.0	0.0	225.0	1629.8	201371
69	035	01	807996	9619586	1545.4	0.0	412.2	1133.2	5875.8	4120406
70	035	02	809579	9620276	966.3	598.4	54.8	313.1	1182.7	242217
71	035	03	808061	9620226	1542.2	1135.9	276.7	129.6	1257.6	105115
72	036	01	804542	9619738	328.2	251.1	34.9	42.3	292.8	7825
73	036	02	803842	9619332	375.2	173.3	48.6	153.3	1064.7	94339
74	038	01	800055	9618008	313.8	155.6	0.1	158.1	1665.1	231632
75	038	02	798497	9619357	255.8	47.3	173.1	35.4	363.4	8836
76	039	01	797238	9619958	531.2	0.0	207.1	324.1	2231.6	435402
77	039	02	795172	9619316	353.3	270.3	1.1	83.6	510.4	24645
78	039	03	794920	9619053	372.6	234.9	78.8	58.9	439.0	16257
79	040	01	793200	9618128	270.0	193.6	5.3	71.0	862.1	31193
80	040	02	792103	9617869	276.4	85.8	117.6	73.0	190.9	8025
81	041	01	790948	9618308	356.7	0.0	193.4	163.2	1328.4	138251
82	042	01	789776	9617596	330.5	181.3	0.1	149.3	2739.1	281065
83	042	02	788815	9615725	276.7	89.5	143.3	43.9	98.6	3260
84	043	01	787158	9615782	284.1	178.1	0.1	106.0	648.3	32413
85	044	01	787108	9616632	746.1	0.0	120.7	625.5	1215.8	338929
86	044	02	787264	9617452	398.8	120.0	81.2	197.7	456.8	54334
87	044	03	786249	9617992	427.1	0.0	169.5	257.6	1345.9	196065
88	045	01	785576	9618104	810.7	408.7	294.9	107.2	619.4	29493

Table 3.2 (3) Sand Bars Summary Inventory (Secondary)

No.	Photo Number	Bar No.	Location		River Width	Bank off Length		Bar		
			X	Y		Right	Left	Width	Length	Area(m²)
89	045	02	785571	9618315	808.4	572.7	85.2	150.6	179.2	12931
90	045	03	784734	9617993	1214.9	287.9	0.2	927.2	2919.4	1665206
91	045	04	782832	9614716	247.2	128.5	0.0	118.7	1801.5	92434
92	046	01	781582	9614570	253.1	132.4	0.2	120.9	968.5	58088
93	046	02	771120	9613817	292.4	86.9	134.8	70.7	369.2	18663
94	047	01	779166	9615992	501.5	94.5	0.0	407.0	2281.5	475768
95	048	01	777790	9618620	417.3	0.0	135.1	282.1	2001.9	569518
96	049	01	776812	9617654	691.7	103.3	148.1	440.3	1250.3	349063
97	049	02	776642	9615810	481.0	183.8	0.0	297.2	842.5	124356
98	049	03	776964	9616038	390.2	0.4	329.8	60.5	182.9	7032
99	050	01	776284	9614856	387.4	84.2	165.8	137.4	375.7	32671
100	050	02	774658	9614046	289.2	0.1	119.7	169.5	750.1	67442
101	051	01	774008	9612780	474.2	159.0	11.9	303.3	2210.6	432752
102	051	02	773882	9610153	666.0	0.2	339.5	326.6	1776.3	392071
103	051	03	773746	9610827	733.2	600.0	10.1	123.2	348.7	21048
104	051	04	773732	9610588	693.7	482.3	134.6	76.9	120.0	3758
105	051	05	773674	9610391	630.5	409.6	173.3	47.7	66.8	1756
106	052	01	772350	9609074	762.3	186.6	0.1	575.6	1955.2	624483
107	052	02	771508	9607472	610.2	0.0	98.5	511.7	1788.7	453265
108	053	01	771028	9606776	404.9	225.8	0.3	179.4	607.5	48016
109	053	02	770752	9605974	550.0	212.0	74.4	263.6	812.8	135675
110	053	03	770798	9605517	557.9	69.3	439.6	49.0	328.4	10563
111	053	04	770554	9605526	524.9	276.5	224.5	23.9	93.9	1409
112	054	01	768824	9604878	719.0	212.3	0.2	506.9	3758.7	1233488
113	055	01	765150	9602480	541.2	82.0	126.0	333.2	1706.4	403349
114	056	01	764564	9599820	452.0	186.3	0.0	265.7	1919.5	352962
115	057	01	762832	9598100	300.8	13.0	189.5	98.3	823.1	59130
116	057	02	762060	9598049	395.9	333.6	21.6	40.7	297.3	6665
117	057	03	761203	9596999	313.1	196.6	0.1	116.3	443.4	36748
118	057	04	761065	9596614	363.6	182.2	120.9	60.4	268.1	9048
119	058	01	760346	9595608	409.2	28.2	190.5	190.5	1793.6	230917
120	060	01	757585	9590894	294.1	0.1	183.9	110.1	143.5	8096
121	062	01	759034	9586414	253.0	121.3	0.0	131.7	1497.5	98989
122	062	02	758422	9585208	246.3	0.1	175.3	70.9	420.1	15807
123	062	03	757698	9584277	291.7	0.2	178.6	113.2	1361.9	98788
124	063	01	758154	9581510	203.2	92.3	42.2	68.8	244.2	9482
125	064	01	758746	9581700	497.9	82.6	225.4	190.0	367.9	35089
126	064	02	758566	9577936	628.8	510.4	0.1	118.5	476.6	27967
127	064	03	758728	9576624	591.3	239.2	117.5	234.7	173.4	25320
128	065	01	757234	9578564	1196.5	0.0	129.3	1067.1	3952.5	2328855
129	065	02	756358	9578092	843.1	647.8	77.8	117.5	213.2	14091
130	065	03	755546	9576409	900.8	151.7	0.5	748.8	2913.1	1389684
131	066	01	754890	9574260	789.6	0.0	217.9	571.7	2596.1	884846
132	066	02	755109	9575253	815.6	396.6	211.1	207.9	270.3	33949

Table 3.2 (4) Sand Bars Summary Inventory (Secondary)

No.	Photo Number	Bar No.	Location		River Width	Bank off Length		Bar		
			X	Y		Right	Left	Width	Length	Area(m²)
133	067	01	754124	9573248	536.7	81.3	113.6	341.8	1020.3	207309
134	067	02	753531	9571779	444.4	0.1	122.3	322.1	1265.7	255659
135	067	03	753382	9571323	422.3	120.6	220.0	81.7	152.2	5914
136	067	04	753013	9570872	564.1	220.7	8.2	335.2	1091.9	209665
137	068	01	752828	9569362	367.0	215.3	0.2	151.5	386.2	29868
138	068	02	752890	9569059	365.1	192.0	80.4	92.8	154.5	5650
139	068	03	752918	9568714	412.9	152.7	101.3	158.8	508.8	54692
140	068	04	752824	9567800	387.4	56.9	202.6	128.0	517.1	30484
141	069	01	752112	9566900	348.0	102.3	0.1	245.6	728.1	89825
142	069	02	751771	9566439	364.4	187.5	104.0	73.0	419.8	18747
143	070	01	751272	9565784	578.1	174.7	136.5	266.9	1398.8	267691
144	070	02	751387	9565552	601.1	0.1	448.3	152.8	606.0	56703
145	070	03	750204	9565070	484.0	265.0	119.9	99.1	481.9	22121
146	071	01	749208	9564565	435.6	177.7	83.6	174.4	1313.6	140127
147	071	02	748657	9564274	405.1	151.2	131.6	122.4	462.8	37963
148	072	01	746092	9561996	474.7	30.4	357.1	87.2	434.0	26351
149	072	02	745676	9561607	414.4	71.1	174.5	168.7	1182.9	149345
150	072	03	745510	9561308	359.3	117.5	149.4	92.4	456.2	28092
151	074	01	743430	9558024	464.9	0.0	159.6	305.4	1133.5	181211
152	075	01	742310	9558385	798.7	134.6	260.5	403.6	1036.2	293564
153	075	02	741342	9557708	883.6	438.0	1.3	446.9	2087.5	625924
154	075	03	742190	9558006	926.0	70.3	694.2	161.5	498.6	47120
155	075	04	741199	9557119	884.0	370.4	121.4	392.1	1262.9	289460
156	075	05	741618	9557147	939.2	129.7	683.0	126.4	331.4	24856
157	075	06	740943	9556657	771.3	480.5	109.3	181.5	1001.2	124353
158	075	07	741210	9556145	759.3	0.0	564.4	194.9	979.1	126008
159	076	01	740305	9555390	518.3	224.5	108.2	185.7	783.2	97463
160	076	02	739561	9553385	653.1	0.2	356.2	296.9	2109.3	403278
161	077	01	739175	9552395	426.2	100.7	161.0	164.5	1025.2	107634
162	077	02	739014	9551603	490.3	237.1	217.5	35.8	131.7	2604
163	077	03	738721	9550649	545.1	183.1	89.3	272.8	1377.6	237396
164	078	01	738580	9549530	357.4	0.3	198.1	159.7	874.7	83024
165	078	02	738119	9548702	280.2	87.8	58.1	134.3	688.5	61045
166	078	03	737501	9547547	332.9	85.7	142.3	104.9	137.9	8737
167	079	01	736726	9546565	435.9	238.5	0.0	197.4	662.2	90826
168	079	02	735895	9545483	701.7	72.0	154.0	475.7	2521.3	630864
169	080	01	733262	9544384	549.5	0.1	302.9	246.7	1542.8	197947
170	080	02	732751	9543757	507.5	176.3	78.4	252.8	899.9	138308
171	081	01	733050	9542652	752.7	333.7	0.2	419.2	2163.5	462014
172	081	02	734609	9540802	684.4	162.2	176.1	346.2	2153.2	617329
173	083	01	729664	9539869	746.8	0.1	222.1	524.7	6089.9	2512334
174	084	01	726628	9536916	494.8	188.0	0.0	306.8	2517.6	517418
175	085	01	725760	9535748	432.8	0.2	223.6	208.9	571.4	67965
176	085	02	725298	9535348	324.3	0.1	265.1	59.1	452.6	16320

Table 3.2 (5) Sand Bars Summary Inventory (Secondary)

No.	Photo Number	Bar No.	Location		River Width	Bank off Length		Bar		
			X	Y		Right	Left	Width	Length	Area(㎡)
177	086	01	723976	9534073	392.5	0.0	84.0	308.5	1869.6	250152
178	086	02	723538	9533411	349.6	153.2	62.9	133.5	231.5	10166
179	086	03	723418	9533015	360.7	212.2	102.3	46.2	223.6	6087
180	087	01	723485	9531570	540.1	113.5	307.7	118.9	438.2	27536
181	087	02	723346	9530556	622.1	170.8	0.0	451.3	2372.5	599157
182	087	03	723619	9529306	583.1	88.9	193.0	301.2	1001.4	200010
183	088	01	723622	9527858	414.6	130.6	112.4	171.7	1415.3	128916
184	088	02	723748	9526825	367.6	0.7	212.5	154.9	970.5	107988
185	089	01	724474	9523672	383.8	44.6	171.2	168.0	1012.4	118994
186	090	01	725728	9521832	310.7	254.2	0.0	56.5	210.1	8290
187	090	02	726143	9519898	594.7	156.7	171.2	266.9	2834.6	474679
188	092	01	726965	9515126	231.4	0.0	183.8	47.7	171.9	4882
189	092	02	726999	9517177	598.7	161.2	191.9	245.6	1186.0	194995
190	092	03	727011	9517745	674.4	488.8	34.3	151.3	474.6	48169
191	092	04	727030	9517531	350.8	280.4	0.0	70.4	297.6	13299
192	093	01	730170	9515212	578.1	0.0	225.2	353.0	1783.0	444438
193	094	01	730644	9514790	547.6	194.4	182.4	170.8	390.6	35355
194	094	02	730735	9514636	540.2	325.5	131.4	83.2	217.9	10327
195	094	03	731937	9514340	594.5	0.1	222.0	372.6	2109.4	512501
196	094	04	733177	9513369	347.1	129.9	42.8	174.4	407.3	48077
197	096	01	735800	9510848	257.6	193.3	0.0	64.2	863.0	44039
198	097	01	735820	9506884	718.3	0.1	259.9	458.4	1986.5	624406
199	097	02	736470	9505750	405.8	258.8	0.1	147.0	1495.5	120840
200	098	01	737398	9505390	309.9	117.5	0.1	192.4	463.4	50951
201	098	02	738573	9504818	509.4	0.1	217.1	292.5	1876.0	405471
202	099	01	737685	9501820	1499.8	467.2	0.0	1032.5	3042.2	2075526
203	099	02	738498	9501730	1442.8	102.8	1197.6	142.4	469.8	45990
204	099	03	738369	9501441	1496.2	67.9	1152.9	275.4	273.3	38874
205	099	04	737369	9500165	543.7	0.0	442.3	101.5	1841.2	124449
206	100	01	736730	9499610	313.7	0.0	224.4	89.2	628.4	37200
207	100	02	735699	9498172	410.5	117.6	0.0	292.9	1002.3	149003
208	100	03	736083	9497426	338.4	75.7	129.8	132.8	235.1	20865
209	101	01	736095	9494030	886.5	317.6	0.1	569.0	2394.1	754054
210	101	02	736495	9493798	902.2	117.6	706.0	78.6	187.4	7893
211	101	03	736397	9493464	794.1	46.4	634.5	113.1	190.8	9994
212	102	01	735264	9491925	529.9	0.0	124.8	405.1	2101.8	430259
213	102	02	734310	9490871	501.8	236.2	30.0	235.5	635.7	75289
214	103	01	733717	9490033	695.9	310.9	0.0	385.0	1773.6	403516
215	103	02	733710	9489545	709.8	192.8	429.6	87.4	448.2	27834
216	103	03	733490	9489463	704.8	357.3	308.8	38.7	159.3	3244
217	103	04	733276	9489261	506.2	426.9	32.8	46.5	208.1	6299
218	103	05	733144	9488766	446.7	165.5	31.8	249.4	1129.7	170869
219	103	06	732474	9487776	394.1	268.6	0.0	125.5	245.2	15261
220	105	01	730336	9485054	492.0	169.8	69.0	253.2	2966.0	468346

Table 3.2 (6) Sand Bars Summary Inventory (Secondary)

No.	Photo Number	Bar No.	Location		River Width	Bank off Length		Bar		
			X	Y		Right	Left	Width	Length	Area(m²)
221	106	01	727170	9481700	390.1	1.1	187.8	201.6	1736.9	211604
222	107	01	726992	9480620	1025.8	188.5	136.4	700.9	2784.5	1382827
223	108	01	729665	9478425	223.0	156.7	0.0	66.3	683.3	20503
224	109	01	730450	9475410	319.0	200.1	0.1	118.8	806.0	41811
225	109	02	729799	9474366	351.3	119.2	138.6	93.6	312.6	19054
226	111	01	728167	9473450	342.4	0.0	155.8	186.6	584.4	48468
227	111	02	727727	9472910	456.0	142.3	264.9	48.7	144.7	4030
228	111	03	727479	9472687	483.3	207.0	140.2	136.1	431.6	40650
229	111	04	727592	9472424	427.1	46.3	346.9	33.9	63.5	1408
230	111	05	727370	9472006	398.0	145.1	121.6	131.4	225.3	15554
231	111	06	727392	9471551	430.6	153.7	129.7	147.2	198.8	12912
232	112	01	727244	9471308	492.1	342.5	0.1	149.5	533.9	31267
233	112	02	727426	9470147	837.9	246.2	36.9	554.8	1968.6	671984
234	112	03	727491	9471104	502.9	162.9	277.8	62.1	143.3	5761
235	112	04	727127	9470404	770.6	704.5	0.1	66.1	784.6	32988
236	112	05	727987	9469299	608.5	32.7	182.0	393.9	984.3	248607
237	113	01	728253	9468543	407.6	146.0	32.7	228.9	489.4	61730
238	113	02	728987	9467909	353.9	78.1	199.9	75.9	129.9	6810
239	113	03	729174	9467723	368.2	0.1	222.7	145.5	246.9	21194
240	113	04	729814	9466878	400.5	167.7	70.1	162.8	497.5	36469
241	113	05	730018	9466625	418.4	309.4	12.7	96.5	409.9	26663
242	114	01	730700	9466342	379.2	150.8	106.1	122.3	305.9	24919
243	114	02	732533	9464963	285.3	183.2	0.1	102.1	700.7	51063
244	115	01	733505	9463194	400.1	91.2	228.9	80.0	390.3	21704
245	115	02	733527	9462672	397.7	129.7	158.5	109.5	571.6	35657
246	115	03	733519	9461092	277.1	53.0	145.9	78.2	136.3	4576
247	115	04	733465	9460625	435.9	105.3	166.7	163.9	678.0	68192
248	116	01	733340	9460210	534.5	339.3	137.9	57.4	359.8	12913
249	116	02	733606	9459211	594.3	172.6	0.1	421.8	2239.9	508332
250	116	03	734266	9458293	456.1	0.0	291.3	164.8	536.5	50201
251	116	04	734434	9457806	466.4	32.1	183.8	250.5	985.3	165242
252	117	01	734970	9456230	1532.2	185.6	2.2	1348.8	3181.3	2476552
253	117	02	735936	9456375	1473.7	22.1	1375.0	76.6	276.7	14100
254	117	03	736132	9456128	1373.6	0.3	1288.3	85.6	399.1	17231
255	118	01	737916	9454287	452.5	65.4	225.0	162.1	597.4	50131
256	118	02	737935	9453614	445.2	169.4	10.6	265.2	643.5	94006
257	120	01	737226	9450670	602.1	73.0	168.2	361.0	1049.0	246002
258	120	02	737280	9450209	632.8	169.0	326.8	136.9	370.0	25057
259	120	03	737476	9449077	584.6	0.1	121.9	462.6	1913.5	577209
260	121	01	737665	9447620	372.1	234.4	0.0	137.7	995.8	92089
261	121	02	738006	9447131	348.9	81.6	202.5	64.8	184.8	7695
262	121	03	738208	9446380	544.0	92.1	100.6	351.3	857.5	155685
263	122	01	738814	9445220	443.4	63.1	176.6	203.8	1440.0	196920
264	122	02	739035	9443730	523.1	268.9	0.0	254.2	1113.0	148804

Table 3.2 (7) Sand Bars Summary Inventory (Secondary)

No.	Photo Number	Bar No.	Location		River Width	Bank off Length		Bar		
			X	Y		Right	Left	Width	Length	Area(㎡)
265	122	03	739249	9443094	592.5	144.6	67.3	380.7	1019.4	254687
266	123	01	739360	9442213	426.0	43.5	282.8	99.7	392.7	24321
267	123	02	739394	9441051	320.1	25.1	148.6	146.4	189.7	16056
268	123	03	739389	9440758	301.6	64.4	104.4	132.8	349.8	25315
269	123	04	739469	9440177	316.1	129.2	74.0	112.9	201.5	15172
270	124	01	739700	9438964	634.8	210.7	0.0	424.1	1539.6	366684
271	124	02	740287	9438484	496.8	127.6	214.8	154.4	521.3	52889
272	124	03	740123	9438463	521.4	329.9	127.7	63.8	259.2	6932
273	124	04	740874	9437664	280.8	142.9	23.7	114.2	524.8	39613
274	125	01	741810	9436695	320.2	15.2	250.9	54.1	101.8	3820
275	125	02	741794	9436558	348.0	47.2	132.6	168.1	463.2	46006
276	125	03	741897	9436250	380.0	133.4	151.6	95.0	406.9	19696
277	125	04	742056	9434566	419.4	112.0	66.2	241.3	1176.9	190932
278	126	01	742470	9431775	322.1	210.8	31.1	80.2	510.0	27848
279	127	01	743560	9430314	334.2	70.6	197.8	65.8	207.0	8489
280	127	02	743525	9429700	422.6	178.1	59.1	185.4	459.5	42389
281	131	01	741205	9418378	553.9	145.0	189.5	219.4	1333.5	190753
282	131	02	741163	9417876	618.6	407.3	77.0	134.4	457.4	27977
283	132	01	742550	9415185	582.7	97.8	104.6	380.3	1411.0	314834
284	132	02	742524	9414608	427.7	151.6	15.1	261.0	648.6	113067
285	138	01	731076	9402590	433.9	212.2	96.8	124.9	410.8	32523
286	142	01	724580	9394014	219.8	163.8	0.1	55.9	263.4	9873
287	147	01	717615	9381880	498.0	181.5	39.2	277.3	1133.5	173545
288	147	02	716829	9381600	194.7	0.0	114.0	80.6	659.8	29919
289	148	01	715446	9381525	369.4	197.4	0.0	172.0	1149.0	137582
290	148	02	713156	9380811	229.6	0.2	154.6	74.8	479.1	22587
291	149	01	712342	9380580	282.8	0.0	182.6	100.2	292.6	15403
292	149	02	710934	9378910	466.1	233.1	48.4	184.6	664.3	82086
293	150	01	711015	9377437	348.4	145.4	0.0	203.0	894.7	105842
294	150	02	711679	9377168	382.5	197.3	42.4	142.8	729.0	53511
295	150	03	712216	9377031	352.4	80.3	168.3	103.9	412.8	20267
296	151	01	712675	9375330	384.8	216.5	0.3	168.3	1849.5	210068
297	151	02	712090	9373320	335.6	0.1	215.0	120.7	1407.0	105941
298	152	01	712335	9370910	465.6	59.1	184.5	222.0	479.3	67658
299	152	02	712481	9370031	367.2	0.1	218.3	149.0	921.0	80974
300	154	01	711290	9365190	272.6	131.8	87.6	53.2	197.4	6700
301	154	02	711064	9364992	340.8	131.6	96.1	113.2	229.4	14233
302	154	03	710726	9364111	320.2	0.1	163.9	156.4	881.4	83455
303	155	01	710252	9363220	291.3	142.2	47.6	101.5	206.3	13509
304	155	02	710240	9362282	447.1	269.0	0.1	178.1	976.6	97587
305	155	03	710471	9361400	281.6	124.0	0.0	157.6	383.2	42551
306	160	01	711640	9348815	575.1	0.0	165.8	409.3	2165.8	526299
307	160	02	710993	9348252	436.7	260.6	106.5	69.6	275.0	13252
308	179	01	737160	9308936	278.4	166.2	0.2	112.4	628.2	48131

3.4 Sand Bar Movement

Regarding the sand bar position of the Primary inventory , the judgement of moving levels was done , compared with the mosaic pictures shooted on Year 1983 and Year 1993 .

The moving levels are divided into 3 levels as following :

No move	... the bar is almost same in a position
Move	... the bar moves downstream
Disappear	... the bar is disappeared

Table 3.3 lists the moving levels of 83 sand bars for the Primary inventory. In this table , 57 sand bars are almost same in it's position. Especially , some sand bars of these are developed along curved channels . Sand bars developed and covered with the vegetation form 12 islands.

15 sand bars are disappeared in Year 1993 and 11 sand bars move downsteram with development by sedimentation or reduction by scouring .

Table 3.3 Moving Levels of 83 Sand Bars during Year 1983-1993

No.	Primary Map No.	Bar No.	Secondary Map No.	Bar No.	Moving Level	Note.
1	74392	1	97	1	no-move	point bar
2	74392	2	97		disappear	
3	74392	3	97	2	no-move	
4	74392	4	98		disappear	
5	74393	1	98	2	no-move	
6	81302	1	100	2	move	united
7	81302	2	100	2	move	united
8	81302	3	99	1	no-move	island
9	81312	1	101	1	no-move	united
10	81312	2	101	1	no-move	united
11	81312	3	101	1	no-move	united
12	81312	4	101	1	no-move	united
13	81312	5	101		disappear	
14	81312	6	102	1	no-move	united
15	81312	7	102	1	no-move	united
16	81321	1	103	5	no-move	
17	81321	2	103	6	no-move	
18	81322	1	103	1	move	
19	81330	1	107	1	no-move	island
20	81331	1	105		disappear	
21	81331	2	105	1	no-move	
22	81331	3	105	1	no-move	developed
23	81341	1	109	1	no-move	reduced
24	81351	1	111	1	no-move	reduced
25	81351	2	112	2	move	
26	81351	3	112	5	move	united
27	81351	4	112	5	move	united
28	81361	1	113	1	no-move	
29	81361	2	113	3	no-move	
30	81361	3	114		disappear	
31	81362	1	c-15		disappear	
32	81372	1	115	2	move	
33	81372	2	116	2	no-move	developed
34	81372	3	116	2	move	united
35	81372	4	116	3	no-move	
36	81382	1	116	4	no-move	
37	81382	2	117	1	no-move	island
38	81382	3	117	1	no-move	united
39	81392	1	120		disappear	

Table 3.3 Moving Levels of 83 Sand Bars during Year 1983-1993

No.	Primary Map No.	Bar No.	Secondary Map No.	Bar No.	Moving Level	Note.
40	81392	2	120	1-3	move	united
41	81392	3	120	1-3	move	united
42	81392	4	120	1-3	move	united
43	81392	5	120	1-3	move	united
44	81392	6	120	1-3	move	united
45	88602	1	121	3	move	developed
46	88603	1	121	3	move	united
47	88603	2	122	1	move	developed
48	88603	3	122	1	move	developed
49	88603	4	122	2-3	move	developed
50	88603	5	122	2-3	move	developed
51	88603	6	123	1	move	
52	88613	1			disappear	
53	88613	2	123	4	no-move	
54	88613	3	124	1	no-move	point bar
55	88613	4	124	1	no-move	united
56	88613	5	124	2	no-move	united
57	88613	6	124	5	no-move	
58	88613	7	125	3	no-move	
59	88613	8	125		disappear	
60	88623	1	125		disappear	
61	88623	2	125	4	no-move	
62	88623	3	125	4	no-move	united
63	88623	4	c-16		disappear	
64	88623	5	126	1	no-move	
65	88633	1	127	2	no-move	
66	88634	1	c-16	13	no-move	reduced
67	88653	1	131	1-2	no-move	
68	88653	2	132	1	no-move	developed
69	88653	3	132	2	no-move	
70	88681	1	138	1	no-move	
71	88690	1	142	1	no-move	
72	88690	2			disappear	
73	96219	1	147	1	no-move	point bar
74	96228	1	149		disappear	
75	96228	2	149	2	no-move	
76	96228	3	c-20	1	no-move	reduced
77	96228	4	150	1	no-move	
78	96228	5	150	2	no-move	

Table 3.3 Moving Levels of 83 Sand Bars during Year 1983-1993

No.	Primary Map No.	Bar No.	Secondary Map No.	Bar No.	Moving Level	Note.
79	96257	1	155		disappear	
80	96278	1	160	1	no-move	
81	104030	1	c-22		disappear	
82	104030	2	c-23	17	no-move	
83	104030	3	c-24	17	no-move	united

Appendix 9: Washout Volume Study

WASHOUT VOLUME STUDY

1. OBJECTIVE

JICA Preparatory Study Team reported that sand bars accumulated in the Parnaiba river were likely to be produced by sediment sands from the Caninde and Poty rivers basins.

In this study, a detailed analysis of the information and data was done. However, the process of sediment production and the mechanism of sediment discharge from both the Caninde and Poty rivers should be clarified and a forecast of the future sediment discharge should be made.

2. OUTLINE OF THE STUDY

The Parnaiba river basin is located in a semi-arid caatinga area and in a transition from caatinga to cerrado area. The lower basin has plenty of rainfall. There are few stormy rains in the area. Rain with high intensity causes surface erosion and sediment formation. Sandy soils of the whole area migth be eroded by the stream.

Field recconaissance survey and washout volume observations were conducted at the proposed site, in order to understand the main cause of the sand bar development in the Parnaiba river. The general field recconaissance was realized from an airplane while the detailed field recconaissance survey and washout volume observations were conducted at the sites.

3. Basin's Natural Conditions

3.1. Geomorphology of the Caninde and Poty Rivers Basins

The Caninde and Poty rivers basins are located in the center of the Piaui state between 4° to 9° south latitude and 40° to 43° west longitude. The basins cover an area of 125,000 km^2 and they have been divided in seven tributary basins. The detailed conditions of the basins are shown below. Table 8.1 shows the catchment area of the tributary basins.

Table. 8.1 Caninde and Poty Rivers Basins Catchment Area

Basins	Tributary Basin	Area km^2
Caninde River		73,000
	Piaui River	39,000
	Fidalgo River	5,000
	Fundo River	6,000
	Das Guaribas River	14,000
Poty River		52,000
	Sambito River	12,000

The Caninda River catchment basin limits with the Serra Dois Irmaos in the south-east and the plateau in the north and west. The basin is mainly occupied by plane fields of 200 to 400m of altitude. The slopes of the area are very gentle and are covered with accumulated fields of weathered platforms and exposed quartz rock areas. Main vegetation in the area is Caatinga.

There are some outcrop rocks in the riverbed. Deep canyons and landslides can be seen at the confluence with the Parnaiba river, however, protection provided by the vegetation (Cerrado) reduces the erosion. This area is entirely covered with sandy soil and there are few drainage streams.

The catchment basin of the Poty river limits with the Serra Grande da Ipiapaba in the east and the low hill of the longa river basin in the north. There are many exposed rocks in the river. Due to the low slope and dense vegetation (Cerrado and Caatinga), erosion is very low in the area.

3.2. Rainfall

In the Caninde river basin, the mean annual rainfall varies from less than 600mm, in the upper stream basin, to 1,200mm in the lower basin. Most of the basin has a rainfall of 600 to 800mm. The rainy season is from January to March.

In the Poty river basin the mean annual rainfall ranges from 800 to 1,300mm. Rainfall distribution is similar to that of the Caninde river basin.

The short term rainfall intensity observations were collected at Simplicio Mendes in the Caninde river basin and at Altos in the Poty river basin.

3.3. Geology

The Parnaiba river basin forms a dipped bed which rises from west to east. An exposed rock belt can be seen in a north-south direction at the eastern edge of the basin. The riverbeds of the Caninde and Poty rivers are formed of paleozoic rocks wich mainly consist of conglomerate, sandstone and slate. The surface of those rocks is covered with sandy soil. There are quartzite rock areas in the south end of the Caninde river basin.

3.4. Land Use

Approximately half of the area of the Caninde river basin, which is classified as caatinga and cerrado, is uncultivated or used as pasture for cattle breeding. Crops of cotton can be found in the east, while in the northern side, industrial crops such as babacu and carnauba palms can be found.

Babacu and carnauba palms crops can also be found in the Poty river basin in the west. About half of the area of this basin is classified as caatinga and cerrado areas and are uncultivated.

3.5. Soil

The Caninde and Poty rivers basins are covered with laterite and silica sand except for the clay soil areas in the eastern part of the basins.

4. METHODOLOGY OF THE STUDY

4.1. Field Reconnaissance Study

Aerial survey was conducted in the Caninde and Poty Rivers as well as field observations. The detailed recconaissance survey was carried out on three sites in mountanious, agricultural and urban areas, for both the Caninde river and the Poti river in order to interpret washout mechanism. Observation items were shown as below.

(1) Morphology
The slope and the scale of the canyons were observed to recognize the possibility of sediment production.

(2) Characteristics of Land Slope
The land slide and debris flow risk was analysed with data on the bank slope.

(3) Land Use
Land use, as well as vegetation distribution and density were studied.

(4) River Characteristics
Sediment transportation by runoff discharge and the future tendency of the riverbed sediments were observed.

4.2. Washout Volume Observation

River discharge measurement was carried out in the dry season; however, there was not enougth water to observe washout volume at Amaramte and Teresina.

Washout volume observation and river discharge measurements were carried out in the rainy season at Amarante, in the Caninde river, and Usina Santana, in the Poty river. The observation points were chosen in order not to suffer the backwater influence of the flooded water level of the Parnaiba river.

Table. 8.2 : Data of the Field Study

Station	Rainy season		
	Area (m^2)	Velocity (m/sec)	Discharge (m^3/sec)
Caninde river			
Sao Francisco Ayres	1.11	0.32	0.36
Amarante			
Poty river			
Usina Santana	19.3	0.73	14.09

5. Results of the Study

5.1. Geomorphology

The reconaissance study results show that the Caninde river and the Poty river form a shallow canyon. The exposed rock in their riverbeds keeps them stable. When sediment is produced by a slope slide or top soil erosion, the drainage stream extends toward a collapsed area. But the altitude of the confluence point with the principal river is constant due to the outcrop rock. It seems that the gentle variation of the riverbed slope is the cause of low sediment transportation.

The basin is covered by Caatinga and Cerrado forests with few drainage streams. This phenomena is due to the high infiltration capacity of the composed soils and the short term rainfall intensity. Most of the torrential rivers have perennial bushes in a major part of their riverbeds. It seems that sediment production and discharge were low in recent years.

In the upper area of the Caninde river basin, sediment volume can be observed between the torrent bank and the eroded hill. Accumulated soils from 0 to 3m in thickness were observed by profile pits and boring data in this area. It seems that sediments are still moving now; although, the gentle slope and small amount of rainfall lessen this phenomena.

5.2. Rainfall

In the Caninde and Poty rivers basins there are seven (7) weather stations where long term rainfalls were recorded (from 1910 to 1993). This rainfall data did not have long term rainfall trend. Data reveals that the hydrological tendencies for sediment production are not likely to happen in the future. Since the accomplishment of the Boa Esperansa Dam in 1967, two heavy floods have occurred in 1974 and 1985. The return period of these floods were one in five (5) years and one in fifteen (15) years (See Fig. 8.3).

There are six (6) weather stations in Piaui State, where short term rainfall intensity (6hr) is recorded (See Table. 8.3). This observation data is the shortest in duration in the Parnaiba basin. The Piloto Longa station is located in the Caninde river while Morro do Cavalos station is located in the Poty river Basin. Rainfall data shows that high intensity rainfall concentrates clearly within 6hr. In data from 1992 to 1993, the occurrence of 3mm/10 min high intensity rainfall which causes surface runoffs happened twenty five (25) times in the rainy season. But rainfall of over 10mm/day occurred only eighteen (18) times. Maximum daily rainfall was 70mm registered in January, 1993 (See Table. 8.3) and the distribution of conditions were concentrated. Therefore few sediment discharge migth occur.

5.3. Geology

In Conceica do Caninde located in the upper basin of the Caninde river, a boring test was conducted for the construction planning of the multipurpose dam. The study report showed a 14m sand sedimentation in the riverbed. The 2m–5m surface soil is fine sand without gravel and is moved as sediment discharge by flood waters. Althoguh due to the gentle slope of the riverbed, which has 1/3,000 longitudinal slope, the riverbed sand is kept stable.

5.4. Land Use

Population statistics from 1550 to 1980 show that the Nordeste region had the largest population in Brasil until 1980. However, the Piaui state had only a small share of the population and low growth rates (See Fig. 8.14). Most of the Nordeste region developed from the east coast as the sugar cane farms. However, the main reason of the development of the Piaui state was the upland crop cultivation along with the pasture cultivation for cattle breeding from the 17th century which diminished erosion year by year. However, after 300 years, development has produced sediments which are transported by rainfall. In addition, the Caatinga area is the second in extension in the serrado semi arid area. Heavy erosion due to recently constructed roads can be found in the area, although road network density is very low. Apparently, sediment production in the area is not very high.

5.5. Soil

Profile pit observations revealed that rocks in the basin consisted in conglomerate and sandstone, while sediments produced by the weathered rocks were mainly gravel and sandy soils. Near the ground surface there exists original foundation. There is fine and uniformly graded sand in the riverbed. The cross section of the soil distribution shows horizontal layers of yearly floods in the riverbed. The banks of the river, composed of sandy clay or loamy sand, are generally stable to flood waters.

Generally, the area where rainfall is very low is covered by a poor vegetation and the soil of the area is sandy. on the other hand, the wet area is covered by a dense vegetation and its soil is highly stable to erosion and its composed mainly of clay.

At Simplicio Mendes, in the upper area of the Caninde river basin, an infiltration test was conducted by an agricultural project of DENOCS. Basic infiltration rates were reported to be over 40mm/hr and high infiltration capacity soils were reported to be expanded in the area.

114 profile pit observations from DENOCS show the soil textures and infiltration speeds of the whole area of the Piaui state. The area is covered mainly by sandy soils with high infiltration speed (between 25mm/hr and 50mm/hr). This data shows that high intensity rainfall of less than 50mm/hr was infiltrated into the basin.
(See Table. 8.13)

Apparently, both in the Caninde and the Poty rivers, sediment production is low and is discharged in the rainy season. Large sediment production and discharge is not likely to occur because of natural conditions of the area.

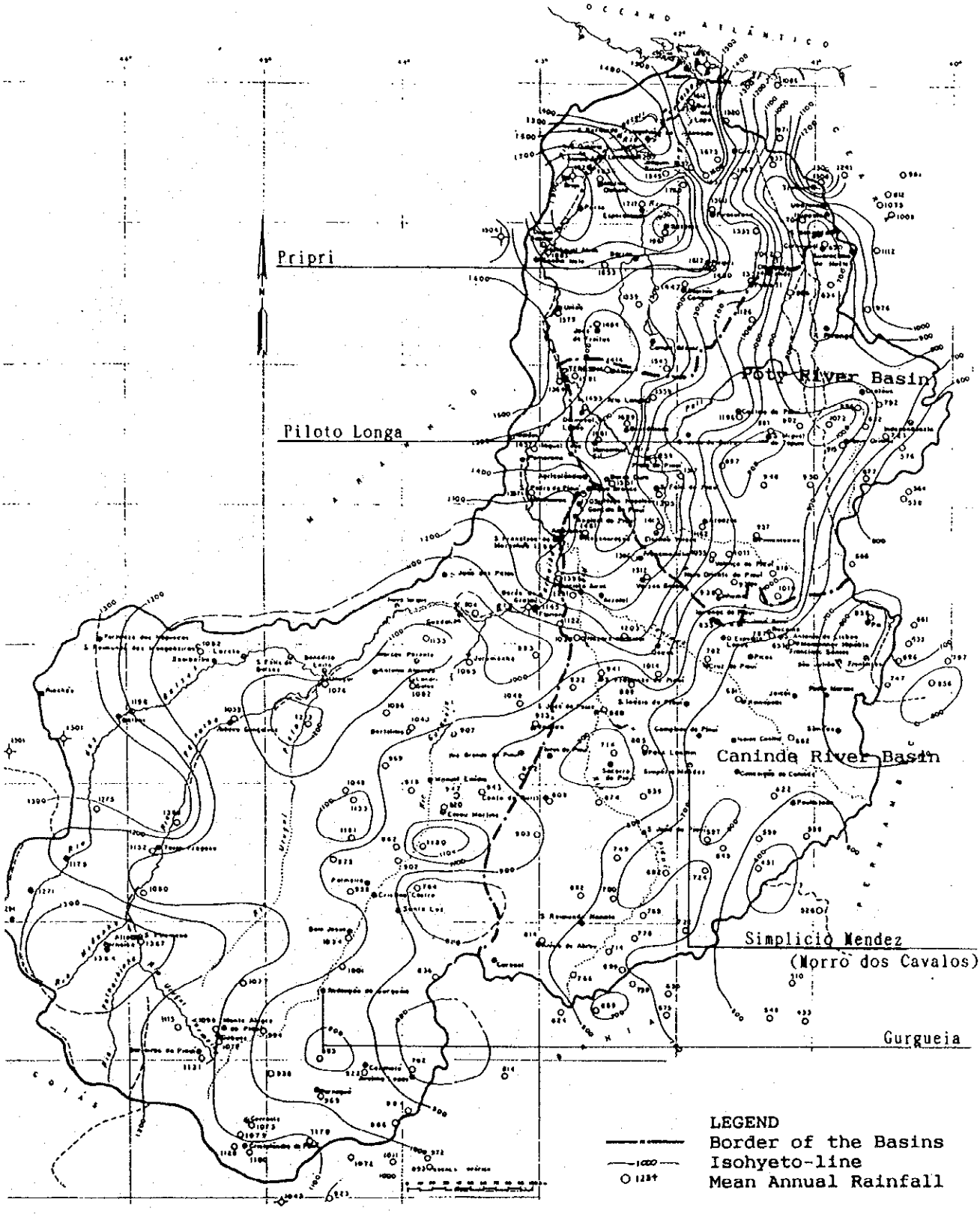

Fig. 8.1 Distrubution of the Mean Annual Rainfall

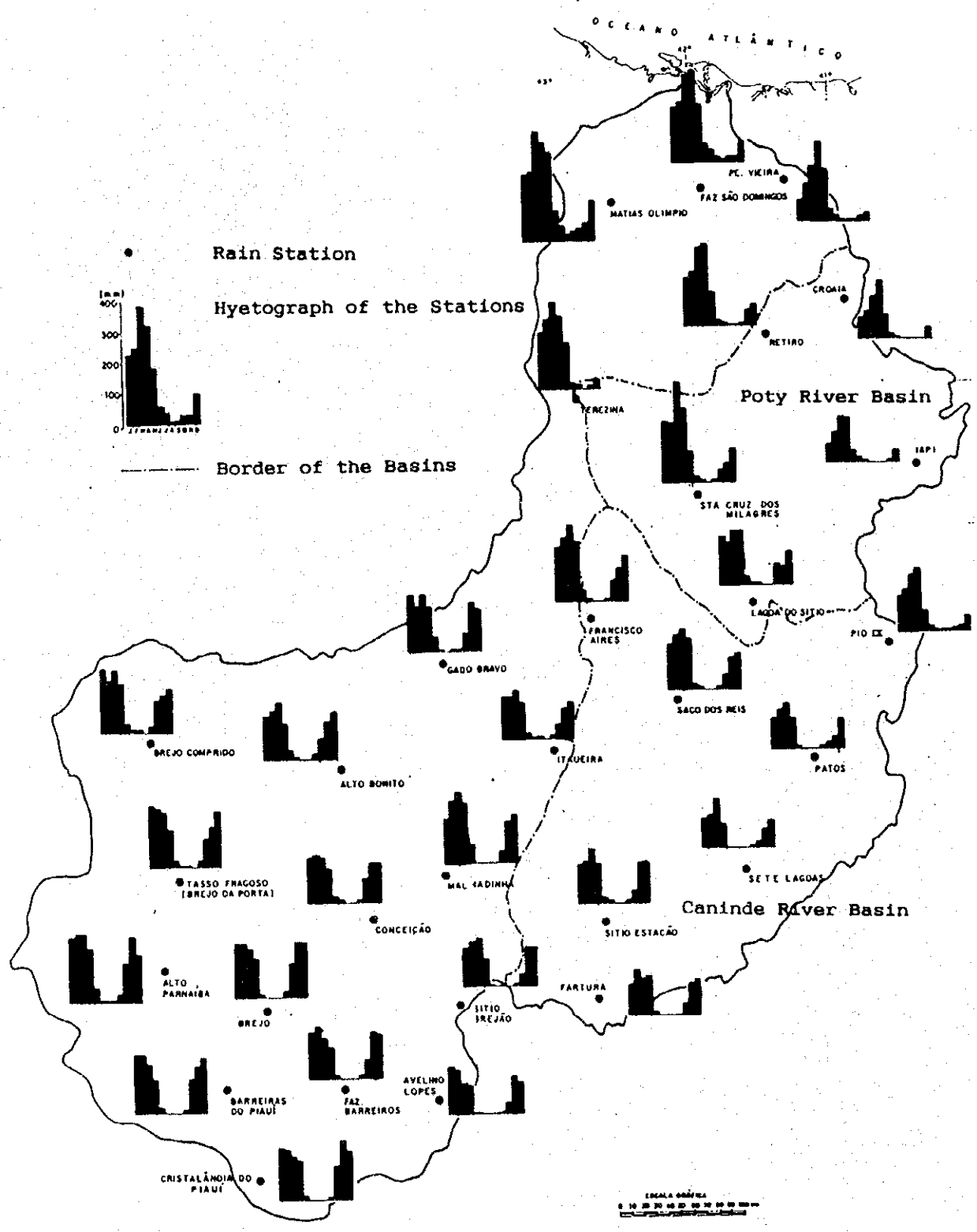

Fig. 8.2 Hyetograph of the Rain Stations

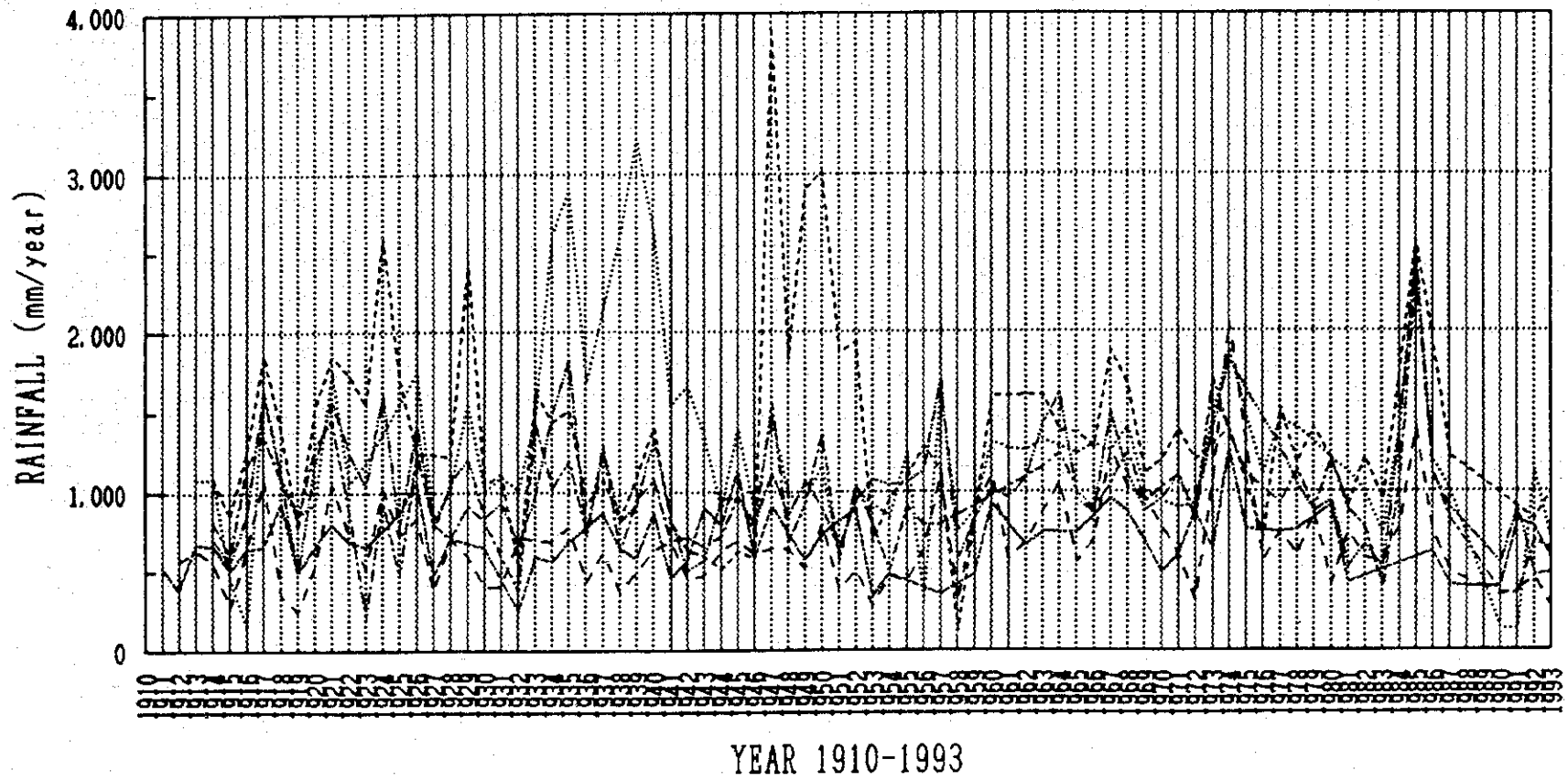

Fig. 8.3 Annual Rainfall Trend (1910-1993)

Table. 8.3

Daily Rainfall Data (Jan. 1993--Dec. 1993)
Simplicio Mendez (Morro dos Cavalos)

Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total
Jan 1				0.0	Feb 1			5.8	5.8	Mar 1	4.6			4.6	Apr 1			3.6	3.6	May 1				0.0	Jun 1		6.6		6.6
2				0.0	2				0.0	2			14.6	14.6	2			32.2	32.2	2				0.0	2	4.0			4.0
3				0.0	3				0.0	3				0.0	3				0.0	3				0.0	3			1.0	1.0
4				0.0	4				0.0	4				0.0	4		4.6		4.6	4				0.0	4				0.0
5				0.0	5				0.0	5				0.0	5			4.2	4.2	5				0.0	5			3.6	3.6
6				0.0	6				0.0	6				0.0	6		12.2		12.2	6				0.0	6				0.0
7				0.0	7				0.0	7				0.0	7				0.0	7				0.0	7				0.0
8				0.0	8				0.0	8				0.0	8				0.0	8			8.6	8.6	8				0.0
9				0.0	9			4.5	4.5	9				0.0	9				0.0	9				0.0	9				0.0
10				0.0	10			7.0	7.0	10		2.4		2.4	10				0.0	10	2.0			2.0	10				0.0
11				0.0	11		46.2		46.2	11				0.0	11				0.0	11				0.0	11				0.0
12				0.0	12			5.8	5.8	12				0.0	12				0.0	12				0.0	12				0.0
13				0.0	13			26.2	26.2	13				0.0	13				0.0	13				0.0	13				0.0
14				0.0	14				0.0	14				0.0	14			3.6	3.6	14				0.0	14				0.0
15				0.0	15		23.6		23.6	15				0.0	15				0.0	15				0.0	15				0.0
16				0.0	16				0.0	16		1.8		1.8	16				0.0	16				0.0	16				0.0
17				0.0	17				0.0	17		1.6		1.6	17			7.8	7.8	17				0.0	17				0.0
18				0.0	18			6.2	6.2	18				0.0	18				0.0	18				0.0	18				0.0
19	11.4			11.4	19			25.6	25.6	19				0.0	19			10.8	10.8	19				0.0	19				0.0
20				0.0	20		13.2	30.4	43.6	20				0.0	20				0.0	20				0.0	20				0.0
21				0.0	21				0.0	21				0.0	21				0.0	21				0.0	21				0.0
22				0.0	22				0.0	22	45.4			45.4	22				0.0	22				0.0	22				0.0
23	30.0			30.0	23				0.0	23				0.0	23				0.0	23				0.0	23				0.0
24		2.9		2.9	24				0.0	24			48.8	48.8	24				0.0	24				0.0	24				0.0
25				0.0	25				0.0	25				0.0	25				0.0	25				0.0	25				0.0
26	4.0			4.0	26			11.4	11.4	26			7.4	7.4	26				0.0	26				0.0	26				0.0
27			62.2	62.2	27				0.0	27				0.0	27			20.4	20.4	27				0.0	27				0.0
28				0.0	28				0.0	28		15.6		15.6	28				0.0	28				0.0	28				0.0
29			70.2	70.2	29				0.0	29				0.0	29				0.0	29				0.0	29				0.0
30				0.0					0.0	30				0.0	30				0.0	30				0.0	30				0.0
31			4.5	4.5					0.0	31				0.0					0.0	31				0.0					0.0
	45.4	2.9	136.9	185.2		0.0	83.0	122.9	205.9		50.0	21.4	70.8	142.2		0.0	16.8	82.6	99.4		2.0	0.0	8.6	10.6		4.0	6.6	4.6	15.2

Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total
Jul 1				0.0	Aug 1				0.0	Sep 1				0.0	Oct 1				0.0	Nov 1				0.0	Dec 1				0.0
2			4.0	4.0	2				0.0	2				0.0	2				0.0	2				0.0	2				0.0
3				0.0	3				0.0	3				0.0	3				0.0	3				0.0	3				0.0
4				0.0	4				0.0	4				0.0	4				0.0	4				0.0	4				0.0
5				0.0	5				0.0	5				0.0	5				0.0	5				0.0	5				0.0
6				0.0	6				0.0	6				0.0	6				0.0	6				0.0	6				0.0
7				0.0	7				0.0	7				0.0	7				0.0	7	2.6			2.6	7				0.0
8				0.0	8				0.0	8				0.0	8				0.0	8				0.0	8				0.0
9				0.0	9				0.0	9				0.0	9				0.0	9				0.0	9				0.0
10				0.0	10				0.0	10	2.0			2.0	10				0.0	10				0.0	10				0.0
11				0.0	11				0.0	11				0.0	11				0.0	11	3.0			3.0	11				0.0
12				0.0	12				0.0	12				0.0	12				0.0	12				0.0	12				0.0
13	3.6			3.6	13				0.0	13				0.0	13				0.0	13				0.0	13				0.0
14				0.0	14				0.0	14				0.0	14				0.0	14				0.0	14				0.0
15				0.0	15				0.0	15				0.0	15				0.0	15				0.0	15				0.0
16				0.0	16				0.0	16				0.0	16				0.0	16				0.0	16				0.0
17				0.0	17				0.0	17				0.0	17				0.0	17				0.0	17				0.0
18				0.0	18				0.0	18				0.0	18				0.0	18				0.0	18				0.0
19				0.0	19				0.0	19				0.0	19				0.0	19				0.0	19				0.0
20				0.0	20				0.0	20				0.0	20	3.2			3.2	20				0.0	20				0.0
21				0.0	21				0.0	21				0.0	21				0.0	21				0.0	21				0.0
22	-			0.0	22				0.0	22				0.0	22				0.0	22				0.0	22				0.0
23				0.0	23				0.0	23				0.0	23				0.0	23				0.0	23				0.0
24				0.0	24				0.0	24				0.0	24				0.0	24				0.0	24				0.0
25				0.0	25				0.0	25				0.0	25				0.0	25				0.0	25				0.0
26				0.0	26				0.0	26				0.0	26				0.0	26				0.0	26				0.0
27				0.0	27				0.0	27				0.0	27				0.0	27				0.0	27				0.0
28				0.0	28				0.0	28				0.0	28				0.0	28				0.0	28				0.0
29				0.0	29				0.0	29				0.0	29				0.0	29			7.4	7.4	29				0.0
30				0.0	30				0.0	30				0.0	30				0.0	30				0.0	30				0.0
31				0.0	31				0.0					0.0	31				0.0					0.0	31				0.0
	3.6	0.0	4.0	7.6		0.0	0.0	0.0	0.0		2.0	0.0	0.0	2.0		3.2	0.0	0.0	3.2		5.6	0.0	7.4	13.0		0.0	0.0	0.0	0.0

Daily Rainfall Data (Jan. 1993--Dec. 1993)
Gurgueia

Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total
Jan 1				0.0	Feb 1	26.0			26.0	Mar 1				0.0	Apr 1				0.0	May 1				0.0	Jun 1				0.0
2				0.0	2				0.0	2				0.0	2	36.0	1.4		37.4	2	3.0			3.0	2				0.0
3				0.0	3		2.8	2.2	5.0	3				0.0	3				0.0	3				0.0	3				0.0
4				0.0	4				0.0	4				0.0	4			10.5	10.5	4				0.0	4				0.0
5				0.0	5		1.2		1.2	5				0.0	5		33.0		33.0	5				0.0	5	0.5		6.8	7.3
6				0.0	6				0.0	6				0.0	6		1.4	10.8	12.2	6				0.0	6				0.0
7	39.0	1.8		40.8	7	10.2	10.0	3.3	23.5	7				0.0	7				0.0	7				0.0	7				0.0
8	3.0			3.0	8	0.3	1.8		2.1	8				0.0	8				0.0	8				0.0	8				0.0
9				0.0	9		18.0	0.4	18.4	9	4.5			4.5	9				0.0	9				0.0	9				0.0
10		6.5		6.5	10				0.0	10				0.0	10				0.0	10				0.0	10				0.0
11				0.0	11	2.0	6.7	0.6	9.3	11				0.0	11				0.0	11				0.0	11				0.0
12	0.5			0.5	12	6.0			6.0	12				0.0	12				0.0	12				0.0	12				0.0
13			1.8	1.8	13			17.0	17.0	13				0.0	13				0.0	13				0.0	13				0.0
14		2.5	4.5	7.0	14	11.0		1.0	12.0	14				0.0	14				0.0	14				0.0	14				0.0
15			0.5	0.5	15		8.4	2.0	10.4	15				0.0	15				0.0	15				0.0	15				0.0
16	0.3	2.0		2.3	16				0.0	16				0.0	16			1.0	1.0	16				0.0	16				0.0
17				0.0	17		4.5		4.5	17				0.0	17				0.0	17				0.0	17				0.0
18			0.1	0.1	18			3.5	3.5	18				0.0	18				0.0	18				0.0	18				0.0
19	0.5			0.5	19		1.0		1.0	19				0.0	19				0.0	19				0.0	19				0.0
20				0.0	20				0.0	20				0.0	20				0.0	20				0.0	20				0.0
21	0.4	4.8	6.0	11.2	21				0.0	21	1.0			1.0	21				0.0	21				0.0	21				0.0
22	5.3	0.5		5.8	22				0.0	22				0.0	22				0.0	22				0.0	22				0.0
23	2.5			2.5	23				0.0	23				0.0	23				0.0	23				0.0	23				0.0
24	15.0	2.5		17.5	24				0.0	24				0.0	24				0.0	24				0.0	24				0.0
25			0.5	0.5	25				0.0	25	20.7	29.0		49.7	25				0.0	25				0.0	25				0.0
26	2.8	8.5		11.3	26			3.0	3.0	26		22.0		22.0	26				0.0	26				0.0	26				0.0
27				0.0	27				0.0	27				0.0	27				0.0	27				0.0	27				0.0
28	108.0	8.2	9.0	125.2	28				0.0	28				0.0	28				0.0	28				0.0	28				0.0
29	1.8	12.0		13.8	29				0.0	29				0.0	29				0.0	29				0.0	29				0.0
30	1.2	15.2	2.2	18.6					0.0	30				0.0	30				0.0	30				0.0	30				0.0
31				0.0					0.0	31				0.0					0.0	31				0.0					0.0
	180.3	64.5	24.6	269.4		55.5	54.4	33.0	142.9		26.2	51.0	0.0	77.2		36.0	35.8	22.3	94.1		3.0	0.0	0.0	3.0		0.5	0.0	6.8	7.3

Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total
Jul 1				0.0	Aug 1				0.0	Sep 1				0.0	Oct 1				0.0	Nov 1	2.0			2.0	Dec 1				0.0
2				0.0	2				0.0	2				0.0	2				0.0	2				0.0	2				0.0
3				0.0	3				0.0	3				0.0	3				0.0	3				0.0	3				0.0
4				0.0	4				0.0	4				0.0	4				0.0	4				0.0	4				0.0
5				0.0	5				0.0	5				0.0	5				0.0	5				0.0	5				0.0
6				0.0	6				0.0	6				0.0	6				0.0	6				0.0	6				0.0
7				0.0	7				0.0	7				0.0	7				0.0	7			37.0	37.0	7				0.0
8				0.0	8				0.0	8				0.0	8				0.0	8	1.0			1.0	8				0.0
9				0.0	9				0.0	9	38.0			38.0	9				0.0	9				0.0	9				0.0
10				0.0	10				0.0	10			3.5	3.5	10				0.0	10				0.0	10				0.0
11				0.0	11				0.0	11				0.0	11				0.0	11				0.0	11				0.0
12				0.0	12				0.0	12				0.0	12				0.0	12				0.0	12		5.0	1.2	6.2
13				0.0	13				0.0	13				0.0	13				0.0	13				0.0	13			2.0	2.0
14				0.0	14			6.5	6.5	14				0.0	14				0.0	14				0.0	14			3.0	3.0
15				0.0	15				0.0	15				0.0	15				0.0	15				0.0	15				0.0
16				0.0	16				0.0	16				0.0	16				0.0	16				0.0	16				0.0
17				0.0	17				0.0	17				0.0	17				0.0	17				0.0	17				0.0
18				0.0	18				0.0	18				0.0	18				0.0	18				0.0	18				0.0
19				0.0	19				0.0	19				0.0	19				0.0	19		7.2	0.8	8.0	19				0.0
20				0.0	20				0.0	20				0.0	20				0.0	20				0.0	20				0.0
21				0.0	21				0.0	21				0.0	21				0.0	21				0.0	21				0.0
22				0.0	22				0.0	22				0.0	22				0.0	22				0.0	22				0.0
23				0.0	23				0.0	23				0.0	23				0.0	23				0.0	23				0.0
24				0.0	24				0.0	24				0.0	24				0.0	24				0.0	24		1.0		1.0
25				0.0	25				0.0	25				0.0	25				0.0	25				0.0	25				0.0
26				0.0	26				0.0	26				0.0	26				0.0	26				0.0	26				0.0
27				0.0	27				0.0	27				0.0	27				0.0	27				0.0	27				0.0
28				0.0	28				0.0	28				0.0	28				0.0	28				0.0	28	24.0	3.5		27.5
29				0.0	29				0.0	29				0.0	29				0.0	29			31.2	31.2	29			4.0	4.0
30				0.0	30				0.0	30				0.0	30				0.0	30	18.2	58.2		76.4	30				0.0
31				0.0	31				0.0					0.0	31				0.0					0.0	31				0.0
	0.0	0.0	0.0	0.0		0.0	0.0	6.5	6.5		38.0	0.0	3.5	41.5		0.0	0.0	0.0	0.0		21.2	65.4	69.0	155.6		24.0	9.5	10.2	43.7

Prepr)

Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total
Jan 1				0.0	Feb 1	1.1			1.1	Mar 1	38.4			38.4	Apr 1	1.1	13.3		14.4	May 1			3.5	3.5	Jun 1				0.0
2				0.0	2	2.0			2.0	2		1.0		1.0	2	12.0	1.4	4.0	17.4	2				0.0	2				0.0
3				0.0	3				0.0	3				0.0	3	45.0			45.0	3				0.0	3				0.0
4				0.0	4				0.0	4				0.0	4			13.1	13.1	4				0.0	4				0.0
5				0.0	5				0.0	5				0.0	5			5.2	5.2	5			3.5	3.5	5				0.0
6				0.0	6				0.0	6				0.0	6		0.9	11.4	12.3	6	1.5		2.0	3.5	6	2.8			2.8
7				0.0	7				0.0	7				0.0	7			11.4	11.4	7				0.0	7				0.0
8				0.0	8				0.0	8			2.8	2.8	8				0.0	8			2.0	2.0	8				0.0
9				0.0	9				0.0	9				0.0	9				0.0	9				0.0	9				0.0
10				0.0	10				0.0	10				0.0	10				0.0	10				0.0	10				0.0
11				0.0	11			4.0	4.0	11				0.0	11				0.0	11				0.0	11				0.0
12				0.0	12				0.0	12				0.0	12				0.0	12				0.0	12				0.0
13				0.0	13			2.0	2.0	13				0.0	13				0.0	13				0.0	13				0.0
14				0.0	14	6.0		8.0	14.0	14				0.0	14			9.2	9.2	14				0.0	14				0.0
15	1.4		2.8	4.2	15	1.0			1.0	15				0.0	15				0.0	15				0.0	15				0.0
16	2.0			2.0	16	1.4			1.4	16	4.3	1.8		6.1	16				0.0	16				0.0	16				0.0
17				0.0	17		1.9	7.1	9.0	17	6.7			6.7	17				0.0	17				0.0	17				0.0
18				0.0	18				0.0	18				0.0	18				0.0	18				0.0	18				0.0
19				0.0	19			14.3	14.3	19		1.8		1.8	19				0.0	19				0.0	19				0.0
20				0.0	20	5.0		30.6	35.6	20			1.2	1.2	20				0.0	20				0.0	20				0.0
21				0.0	21	4.1			4.1	21			20.4	20.4	21				0.0	21				0.0	21				0.0
22				0.0	22				0.0	22	10.4		0.5	10.9	22				0.0	22				0.0	22				0.0
23				0.0	23			8.7	8.7	23				0.0	23				0.0	23				0.0	23				0.0
24	57.2			57.2	24				0.0	24		19.8	18.6	38.4	24				0.0	24				0.0	24				0.0
25			2.2	2.2	25				0.0	25	14.2		1.0	15.2	25				0.0	25				0.0	25				0.0
26			5.0	5.0	26				0.0	26	3.1			3.1	26				0.0	26				0.0	26				0.0
27	5.8			5.8	27				0.0	27		4.4		4.4	27				0.0	27				0.0	27				0.0
28		23.5	1.0	24.5	28				0.0	28			45.4	45.4	28		0.8		0.8	28				0.0	28		1.0	0.7	1.7
29				0.0	29			38.4	38.4	29	1.8			1.8	29				0.0	29				0.0	29				0.0
30				0.0					0.0	30		12.2		12.2	30				0.0	30				0.0	30				0.0
31				0.0					0.0	31			25.0	25.0					0.0	31				0.0					0.0
	66.4	23.5	11.0	100.9		20.6	1.9	113.1	135.6		78.9	41.0	114.9	234.8		58.1	16.4	54.3	128.8		1.5	0.0	11.0	12.5		2.8	1.0	0.7	4.5

Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total	Date	12hr	18hr	24hr	Total
Jul 1				0.0	Aug 1				0.0	Sep 1				0.0	Oct 1				0.0	Nov 1				0.0	Dec 1				0.0
2				0.0	2				0.0	2				0.0	2				0.0	2				0.0	2				0.0
3				0.0	3				0.0	3				0.0	3				0.0	3				0.0	3				0.0
4				0.0	4				0.0	4				0.0	4				0.0	4				0.0	4				0.0
5				0.0	5				0.0	5				0.0	5				0.0	5				0.0	5				0.0
6				0.0	6				0.0	6				0.0	6				0.0	6				0.0	6				0.0
7				0.0	7				0.0	7				0.0	7				0.0	7				0.0	7				0.0
8				0.0	8				0.0	8				0.0	8				0.0	8				0.0	8				0.0
9				0.0	9			1.0	1.0	9			4.0	4.0	9				0.0	9				0.0	9				0.0
10				0.0	10				0.0	10				0.0	10				0.0	10				0.0	10				0.0
11				0.0	11				0.0	11				0.0	11				0.0	11				0.0	11				0.0
12				0.0	12				0.0	12				0.0	12				0.0	12				0.0	12				0.0
13				0.0	13				0.0	13				0.0	13				0.0	13				0.0	13				0.0
14				0.0	14				0.0	14				0.0	14				0.0	14				0.0	14			9.0	9.0
15				0.0	15				0.0	15				0.0	15				0.0	15	2.4			0.0	15				2.4
16				0.0	16				0.0	16				0.0	16				0.0	16				0.0	16				0.0
17				0.0	17				0.0	17				0.0	17				0.0	17				0.0	17				0.0
18				0.0	18				0.0	18				0.0	18				0.0	18				0.0	18				2.4
19				0.0	19				0.0	19				0.0	19				0.0	19				0.0	19				0.0
20				0.0	20				0.0	20				0.0	20				0.0	20				0.0	20				0.0
21				0.0	21				0.0	21				0.0	21				0.0	21				0.0	21			2.4	2.4
22				0.0	22				0.0	22				0.0	22				0.0	22				0.0	22				0.0
23				0.0	23				0.0	23				0.0	23				0.0	23				0.0	23				0.0
24				0.0	24				0.0	24				0.0	24				0.0	24				0.0	24				0.0
25				0.0	25				0.0	25				0.0	25				0.0	25				0.0	25				0.0
26				0.0	26				0.0	26				0.0	26				0.0	26				0.0	26				0.0
27				0.0	27				0.0	27				0.0	27				0.0	27				0.0	27				0.0
28				0.0	28				0.0	28				0.0	28				0.0	28				0.0	28				0.0
29				0.0	29				0.0	29				0.0	29				0.0	29			1.0	1.0	29				0.0
30				0.0	30				0.0	30				0.0	30				0.0	30				0.0	30				0.0
31				0.0	31				0.0					0.0	31				0.0					0.0	31				0.0
	0.0	0.0	0.0	0.0		0.0	0.0	1.0	1.0		0.0	0.0	4.0	4.0		0.0	0.0	0.0	0.0		0.0	0.0	1.0	1.0		2.4	0.0	11.4	16.2

Daily Rainfall Data (Jan. 1993--Dec. 1993)

Piloto Longa

Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total
Jan 1				0.0	Feb 1			5.8	5.8	Mar 1	4.6			4.6	Apr 1			3.6	3.6	May 1				0.0	Jun 1		6.6		6.6
2				0.0	2				0.0	2			14.6	14.6	2			32.2	32.2	2				0.0	2	0.4			0.4
3				0.0	3				0.0	3				0.0	3				0.0	3				0.0	3			1.0	1.0
4				0.0	4				0.0	4				0.0	4		4.0		4.0	4				0.0	4				0.0
5				0.0	5				0.0	5				0.0	5			4.2	4.2	5				0.0	5			3.6	3.6
6				0.0	6				0.0	6				0.0	6		12.2		12.2	6				0.0	6				0.0
7				0.0	7				0.0	7				0.0	7				0.0	7				0.0	7				0.0
8				0.0	8				0.0	8				0.0	8				0.0	8			8.6	8.6	8				0.0
9				0.0	9			4.5	4.5	9		2.4		2.4	9				0.0	9				0.0	9				0.0
10				0.0	10			7.0	7.0	10				0.0	10				0.0	10	2.0			2.0	10				0.0
11				0.0	11		46.2		46.2	11				0.0	11				0.0	11				0.0	11				0.0
12				0.0	12			5.8	5.8	12				0.0	12				0.0	12				0.0	12				0.0
13				0.0	13			26.2	26.2	13				0.0	13				0.0	13				0.0	13				0.0
14				0.0	14				0.0	14				0.0	14			3.6	3.6	14				0.0	14				0.0
15				0.0	15		23.6		23.6	15				0.0	15				0.0	15				0.0	15				0.0
16				0.0	16				0.0	16		1.8		1.8	16			7.8	7.8	16				0.0	16				0.0
17				0.0	17				0.0	17		1.6		1.6	17				0.0	17				0.0	17				0.0
18				0.0	18			6.2	6.2	18				0.0	18			10.8	10.8	18				0.0	18				0.0
19	11.4			11.4	19			25.6	25.6	19				0.0	19				0.0	19				0.0	19				0.0
20				0.0	20		13.2	30.4	43.6	20				0.0	20				0.0	20				0.0	20				0.0
21				0.0	21				0.0	21				0.0	21				0.0	21				0.0	21				0.0
22				0.0	22				0.0	22	45.4			45.4	22				0.0	22				0.0	22				0.0
23	30.0			30.0	23				0.0	23				0.0	23				0.0	23				0.0	23				0.0
24		2.9		2.9	24				0.0	24			48.8	48.8	24				0.0	24				0.0	24				0.0
25				0.0	25				0.0	25				0.0	25				0.0	25				0.0	25				0.0
26	4.0			4.0	26			11.4	11.4	26			7.4	7.4	26				0.0	26				0.0	26				0.0
27			62.2	62.2	27				0.0	27				0.0	27			20.4	20.4	27				0.0	27				0.0
28			0.0	0.0	28				0.0	28		15.6		15.6	28				0.0	28				0.0	28				0.0
29			70.2	70.2	29				0.0	29				0.0	29				0.0	29				0.0	29				0.0
30				0.0					0.0	30				0.0	30				0.0	30				0.0	30				0.0
31			4.5	4.5					0.0	31				0.0					0.0	31				0.0					0.0
	45.4	2.9	136.9	185.2		0.0	83.0	122.9	205.9		50.0	21.4	70.8	142.2		0.0	16.2	82.6	98.8		2.0	0.0	8.6	10.6		0.4	6.6	4.6	11.6

Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total	Date	12hr	18hr	24hr	total
Jul 1				0.0	Aug 1				0.0	Sep 1				0.0	Oct 1				0.0	Nov 1				0.0	Dec 1				0.0
2			4.0	4.0	2				0.0	2				0.0	2				0.0	2				0.0	2				0.0
3				0.0	3				0.0	3				0.0	3				0.0	3				0.0	3				0.0
4				0.0	4				0.0	4				0.0	4				0.0	4				0.0	4				0.0
5				0.0	5				0.0	5				0.0	5				0.0	5				0.0	5				0.0
6				0.0	6				0.0	6				0.0	6				0.0	6				0.0	6				0.0
7				0.0	7				0.0	7				0.0	7				0.0	7	2.6			2.6	7				0.0
8				0.0	8				0.0	8				0.0	8				0.0	8				0.0	8				0.0
9				0.0	9				0.0	9	2.0			2.0	9				0.0	9				0.0	9				0.0
10				0.0	10				0.0	10				0.0	10				0.0	10				0.0	10	3.4			3.4
11				0.0	11				0.0	11				0.0	11				0.0	11	3.0			3.0	11				0.0
12				0.0	12				0.0	12				0.0	12				0.0	12				0.0	12				0.0
13	3.6			3.6	13				0.0	13				0.0	13				0.0	13				0.0	13			12.9	12.9
14				0.0	14				0.0	14				0.0	14				0.0	14				0.0	14				0.0
15				0.0	15				0.0	15				0.0	15				0.0	15				0.0	15				0.0
16				0.0	16				0.0	16				0.0	16				0.0	16				0.0	16				0.0
17				0.0	17				0.0	17				0.0	17				0.0	17				0.0	17				0.0
18				0.0	18				0.0	18				0.0	18				0.0	18				0.0	18				0.0
19				0.0	19				0.0	19				0.0	19	3.2			3.2	19				0.0	19				0.0
20				0.0	20				0.0	20				0.0	20				0.0	20				0.0	20				0.0
21				0.0	21				0.0	21				0.0	21				0.0	21				0.0	21				0.0
22				0.0	22				0.0	22				0.0	22				0.0	22				0.0	22				0.0
23				0.0	23				0.0	23				0.0	23				0.0	23				0.0	23				0.0
24				0.0	24				0.0	24				0.0	24				0.0	24				0.0	24				0.0
25				0.0	25				0.0	25				0.0	25				0.0	25				0.0	25				0.0
26				0.0	26				0.0	26				0.0	26				0.0	26				0.0	26				0.0
27				0.0	27				0.0	27				0.0	27				0.0	27				0.0	27				0.0
28				0.0	28				0.0	28				0.0	28				0.0	28				0.0	28				0.0
29				0.0	29				0.0	29				0.0	29				0.0	29			7.4	7.4	29				0.0
30				0.0	30				0.0	30				0.0	30				0.0	30				0.0	30				0.0
31				0.0	31				0.0					0.0	31				0.0					0.0	31				0.0
	3.6	0.0	4.0	7.6		0.0	0.0	0.0	0.0		2.0	0.0	0.0	2.0		3.2	0.0	0.0	3.2		5.6	0.0	7.4	13.0		3.4	0.0	12.9	16.3

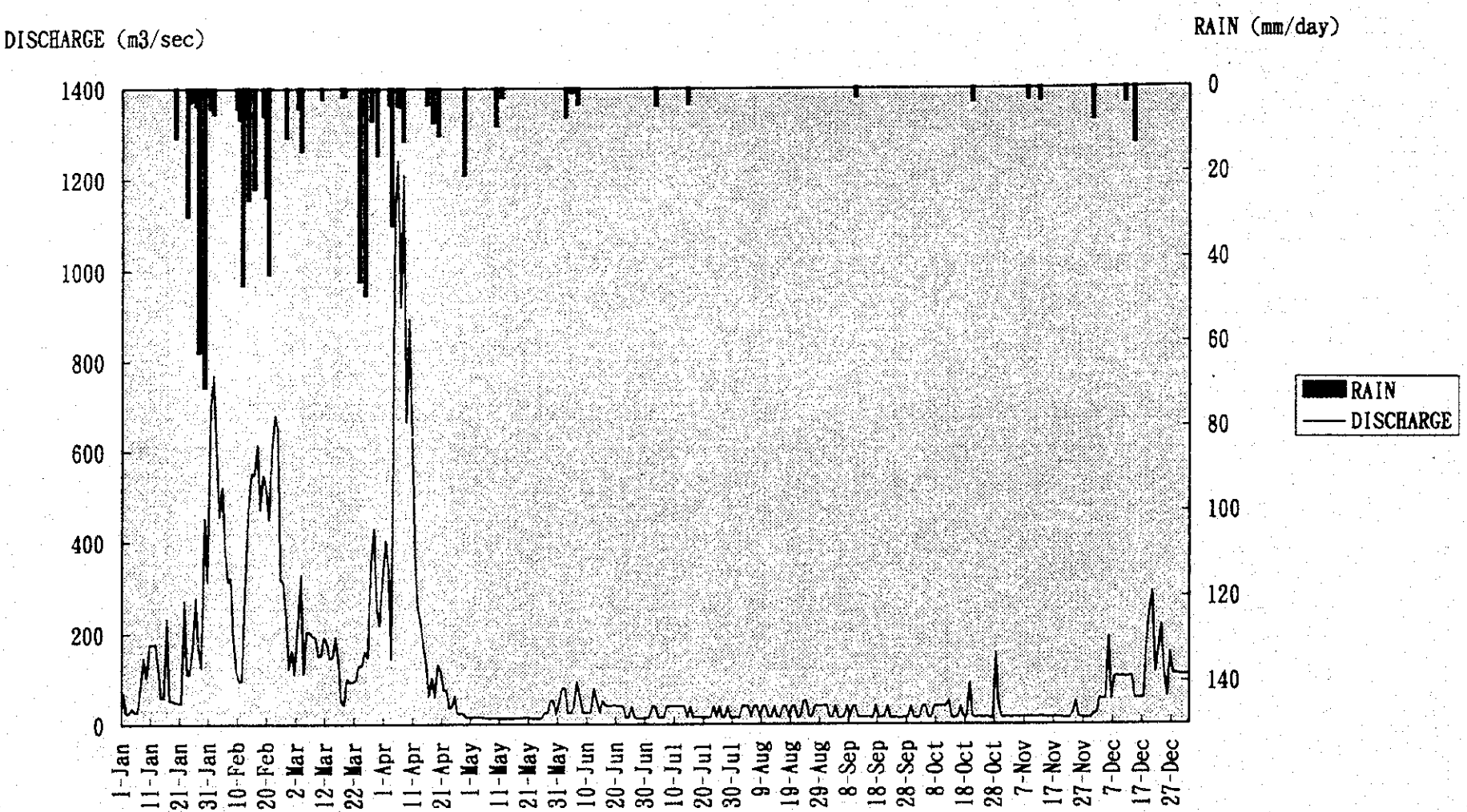

Fig. 8.4 **HYDROGRAPH OF RIO POTI (1993)**

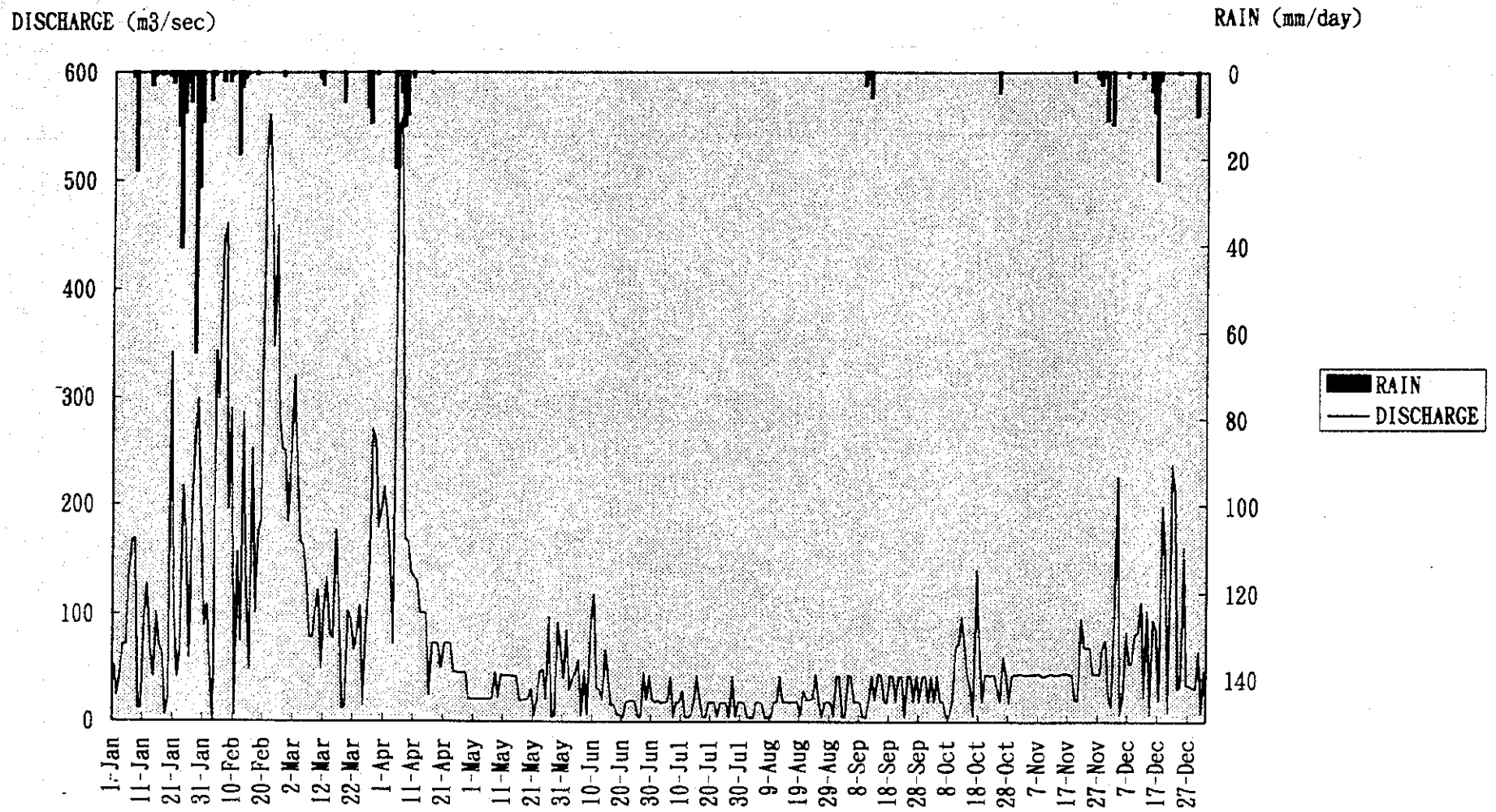

Fig. 8.5 HYDROGRAPH OF RIO CANINDE (1993)

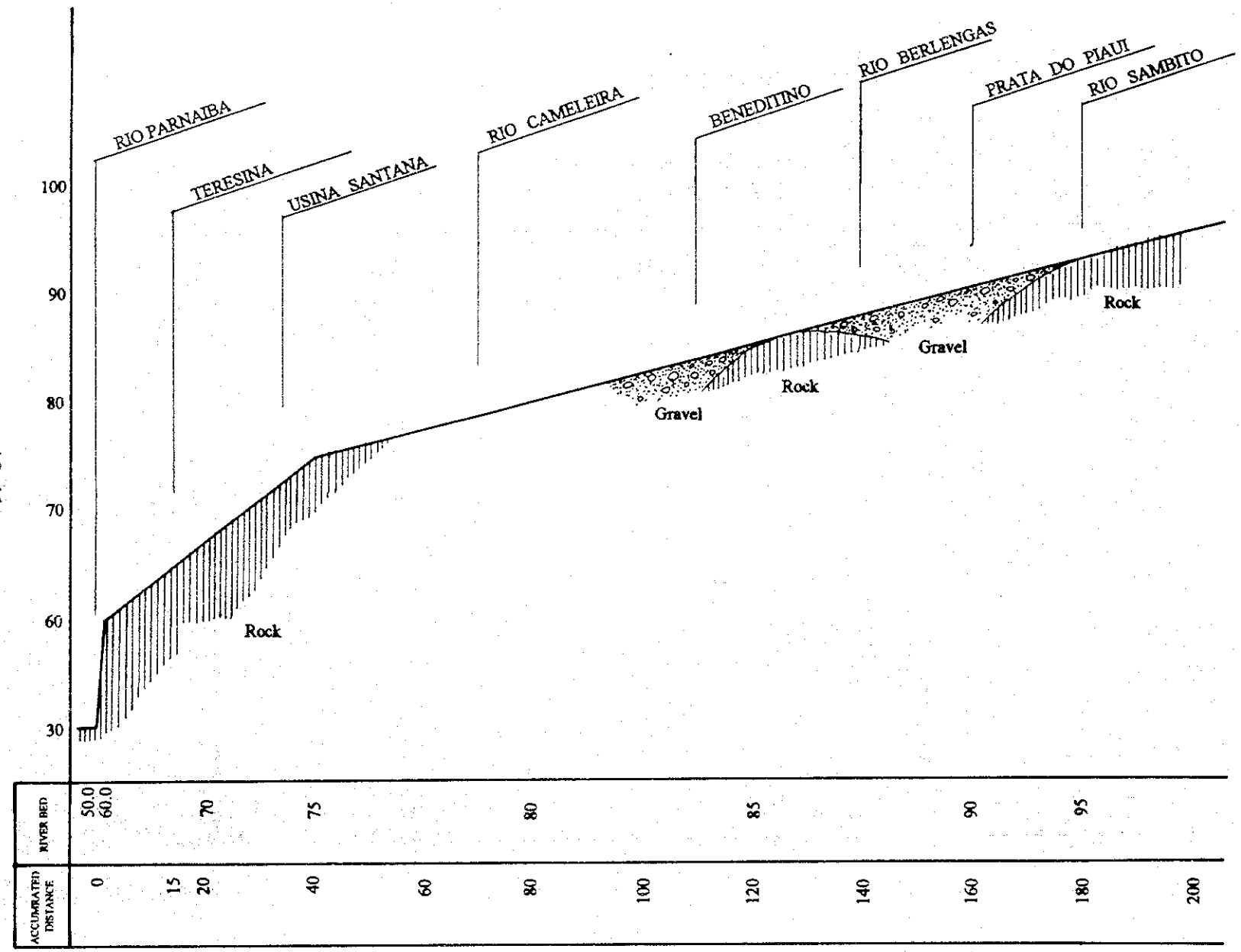

Fig. 8.6 Longitudinal Section of Rio Poti

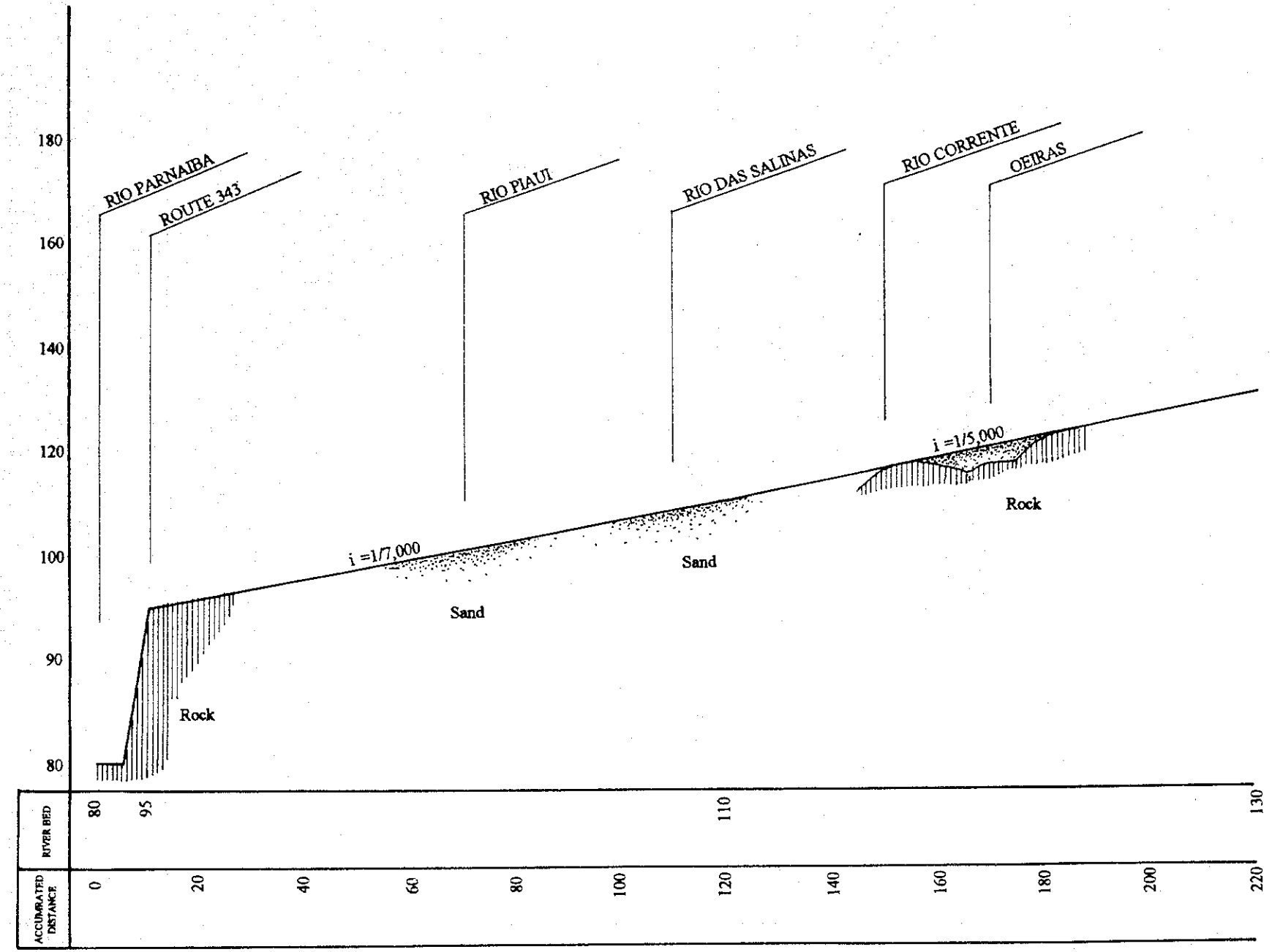

Fig. 8.7 Longitudinal Section of Rio Caninde

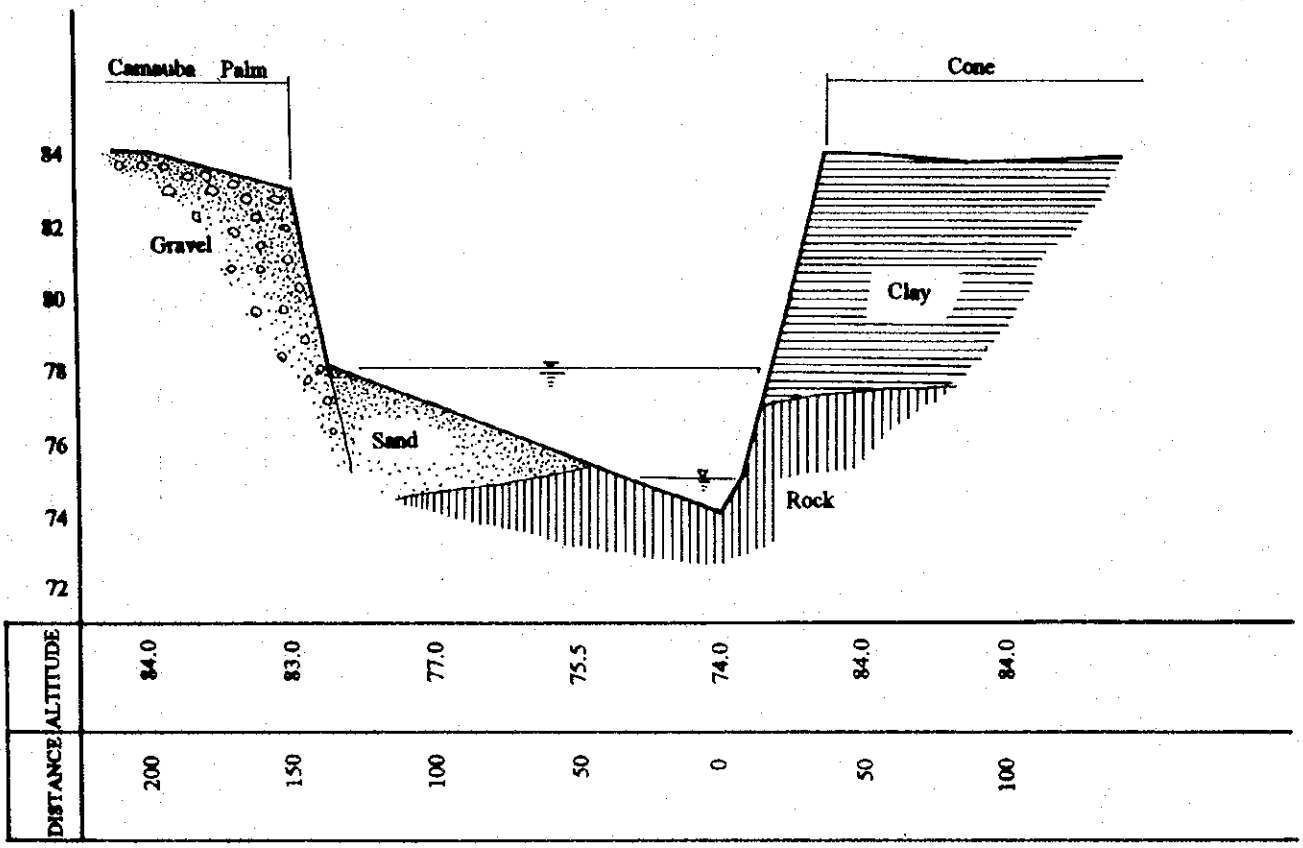

Fig. 8.8 RIO POTI (USINA SANTANA)

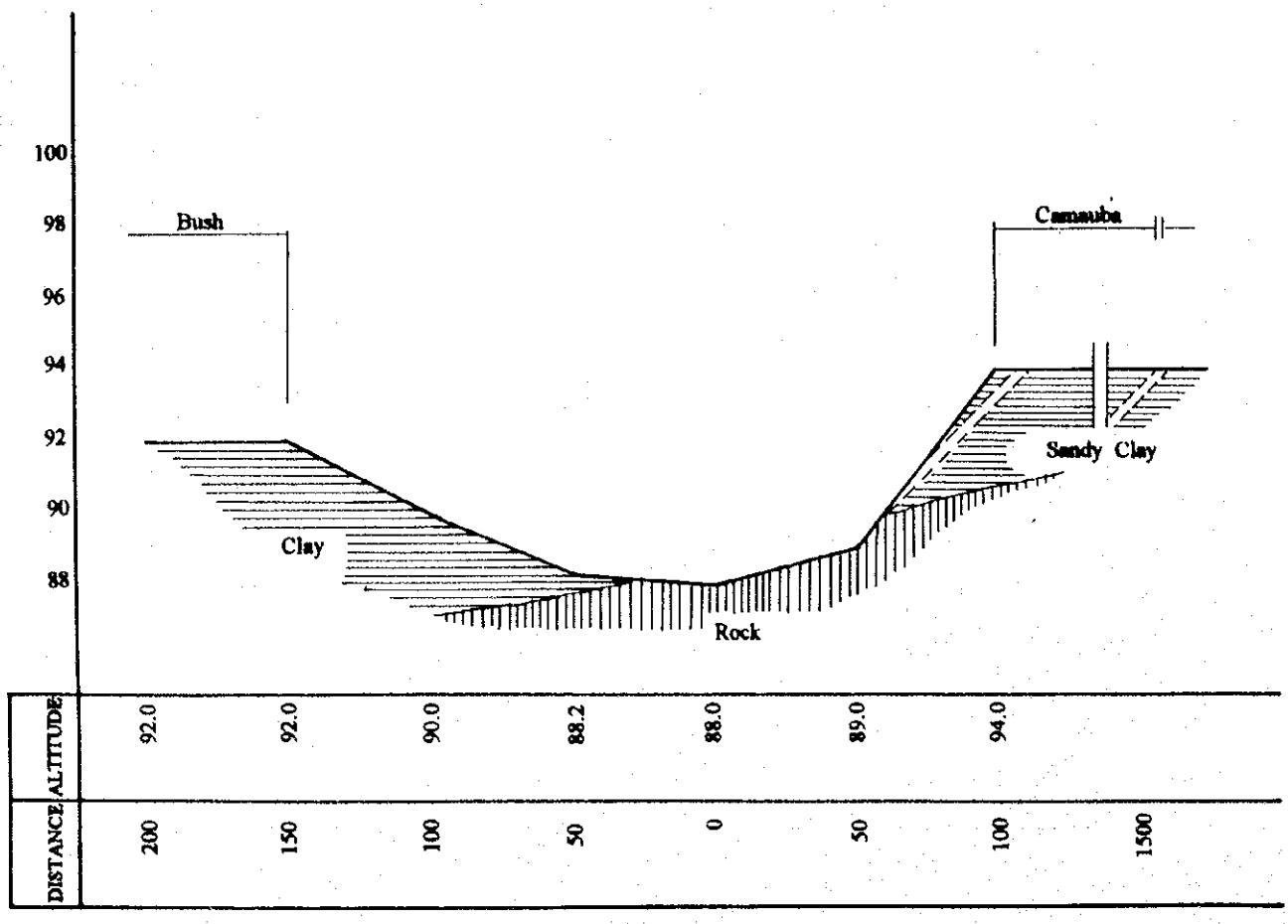

Fig. 8.9 RIO POTI (BENEDITINO)

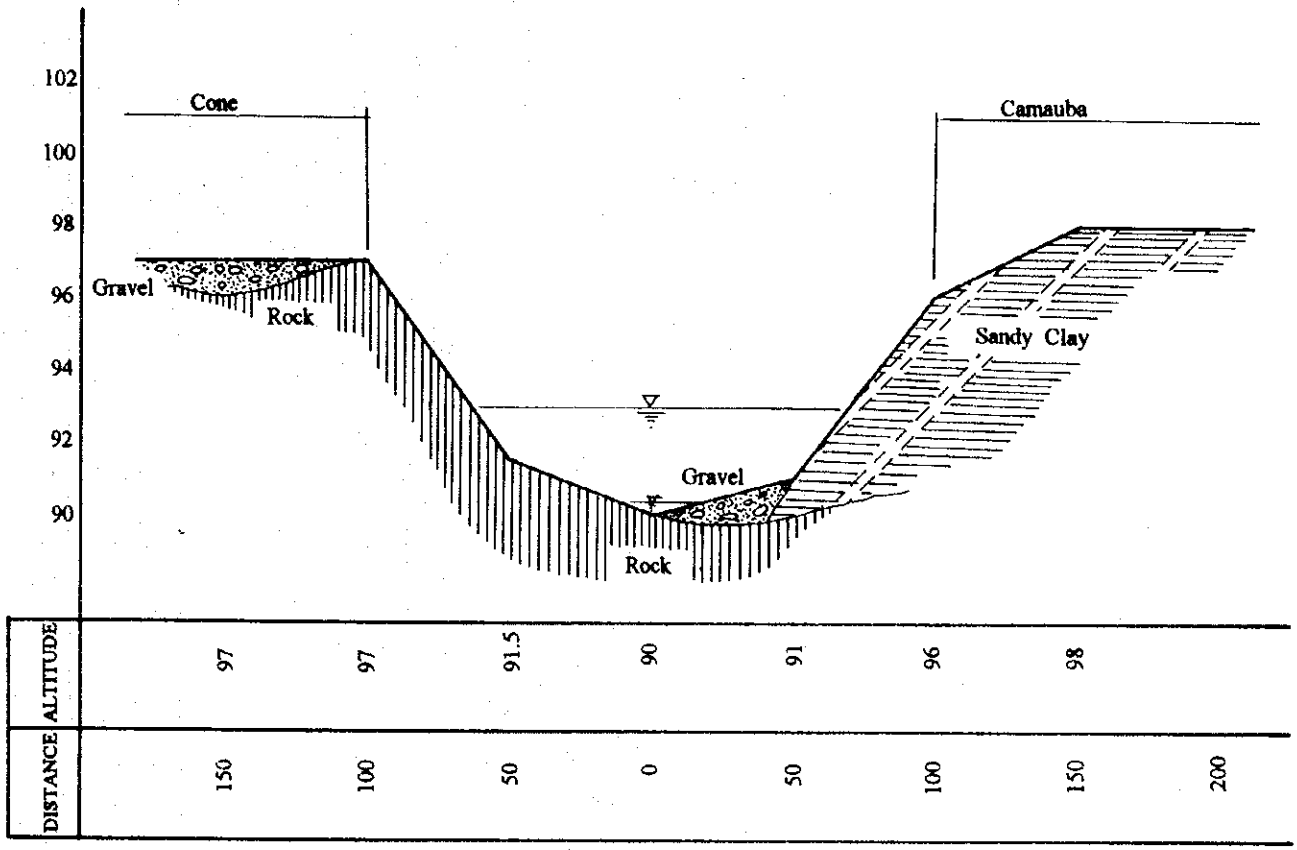

Fig. 8.10 RIO POTI (PRATA DO PIAUI)

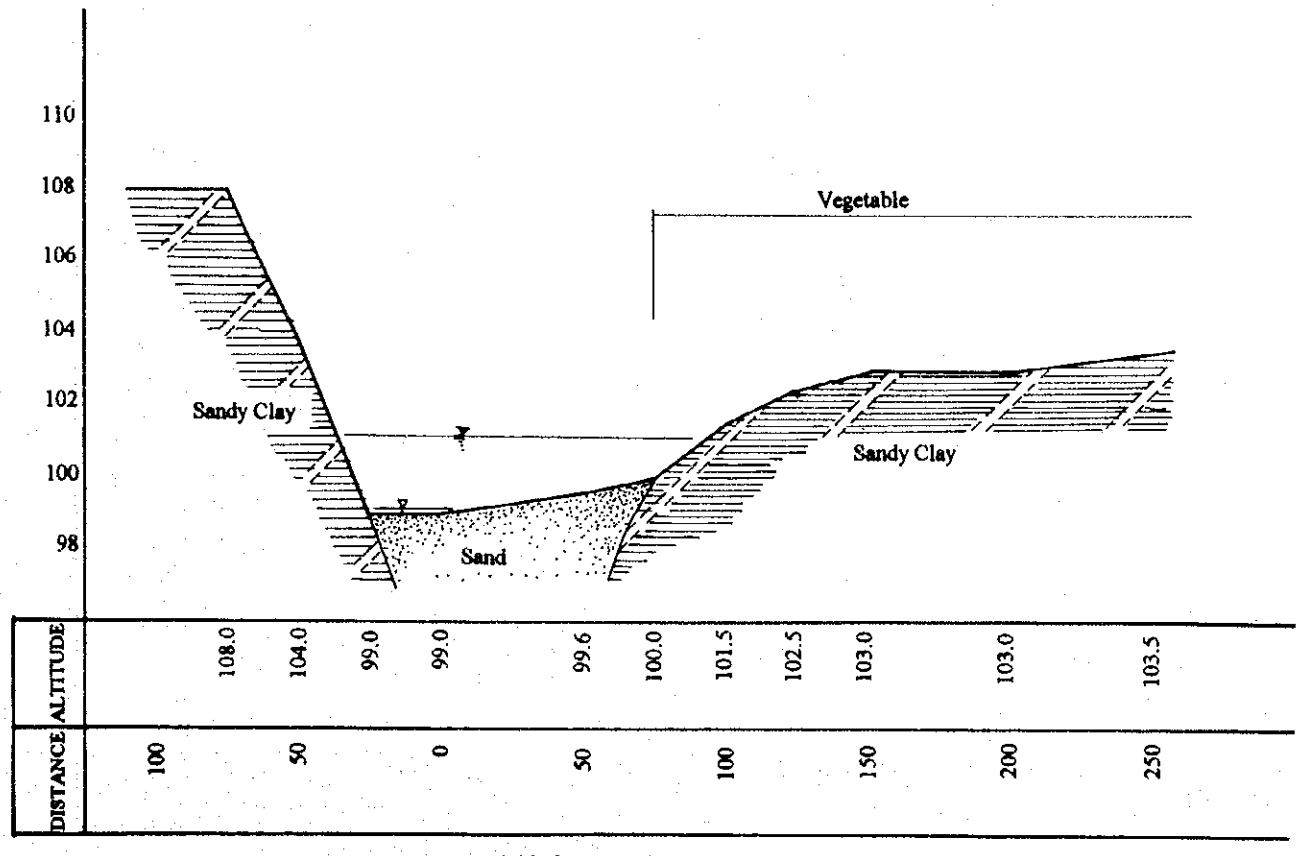

Fig. 8.11 RIO CANINDE (FRANCISCO AYRES)

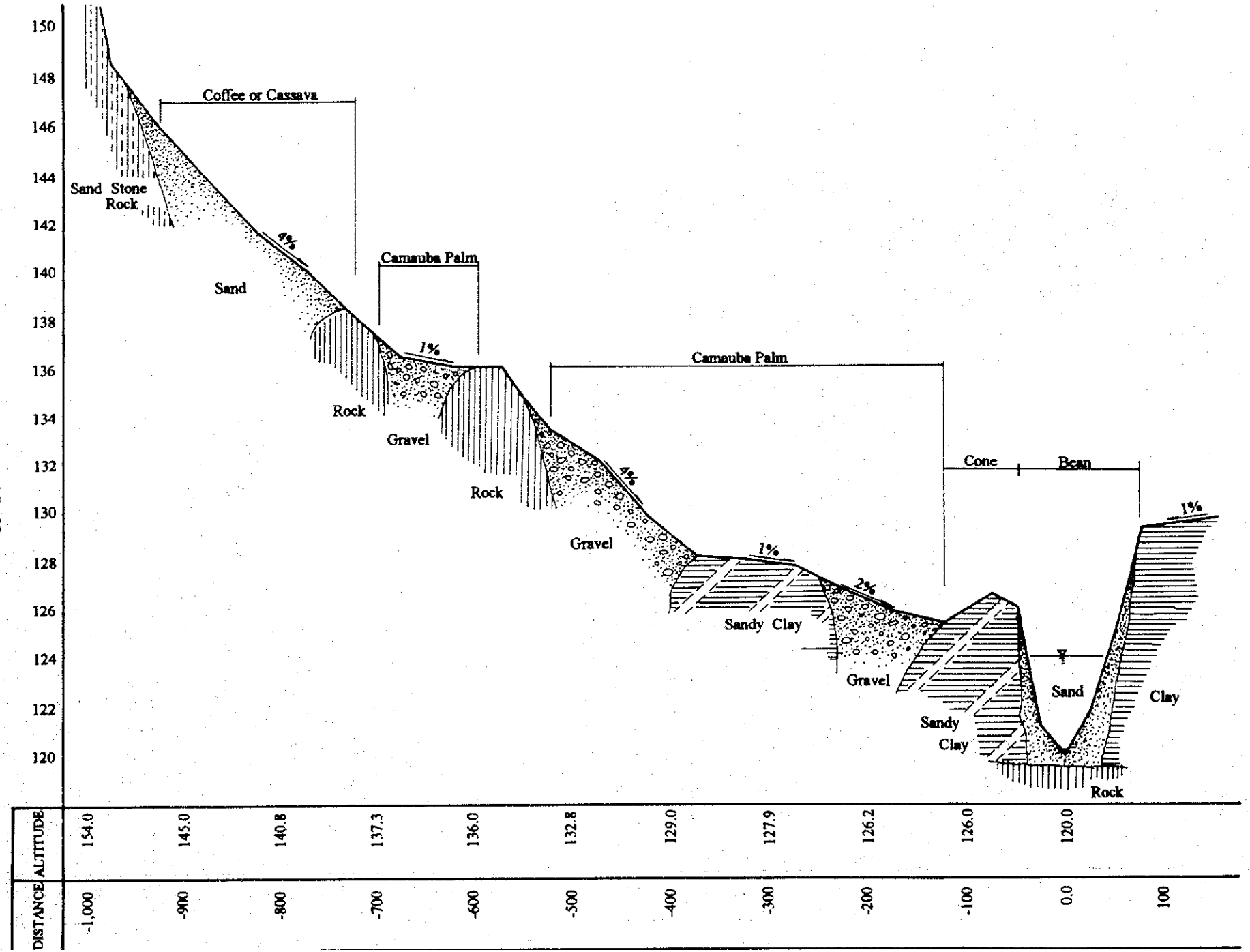
150
148
146
144
142
140
138
136
134
132
130
128
126
124
122
120
Coffee or Cassava
Sand Stone Rock
4%
Sand
Camauba Palm
1%
Rock
Gravel
Camauba Palm
Rock
4%
Gravel
1%
Sandy Clay
2%
Gravel
Cone
Bean
1%
Sand
Clay
Sandy Clay
Rock
DISTANCE
ALTITUDE
-1,000
154.0
-900
145.0
-800
140.8
-700
137.3
-600
136.0
-500
132.8
-400
129.0
-300
127.9
-200
126.2
-100
126.0
0.0
120.0
100

Fig. 8.13 Infiltration Capacity of Piaui State

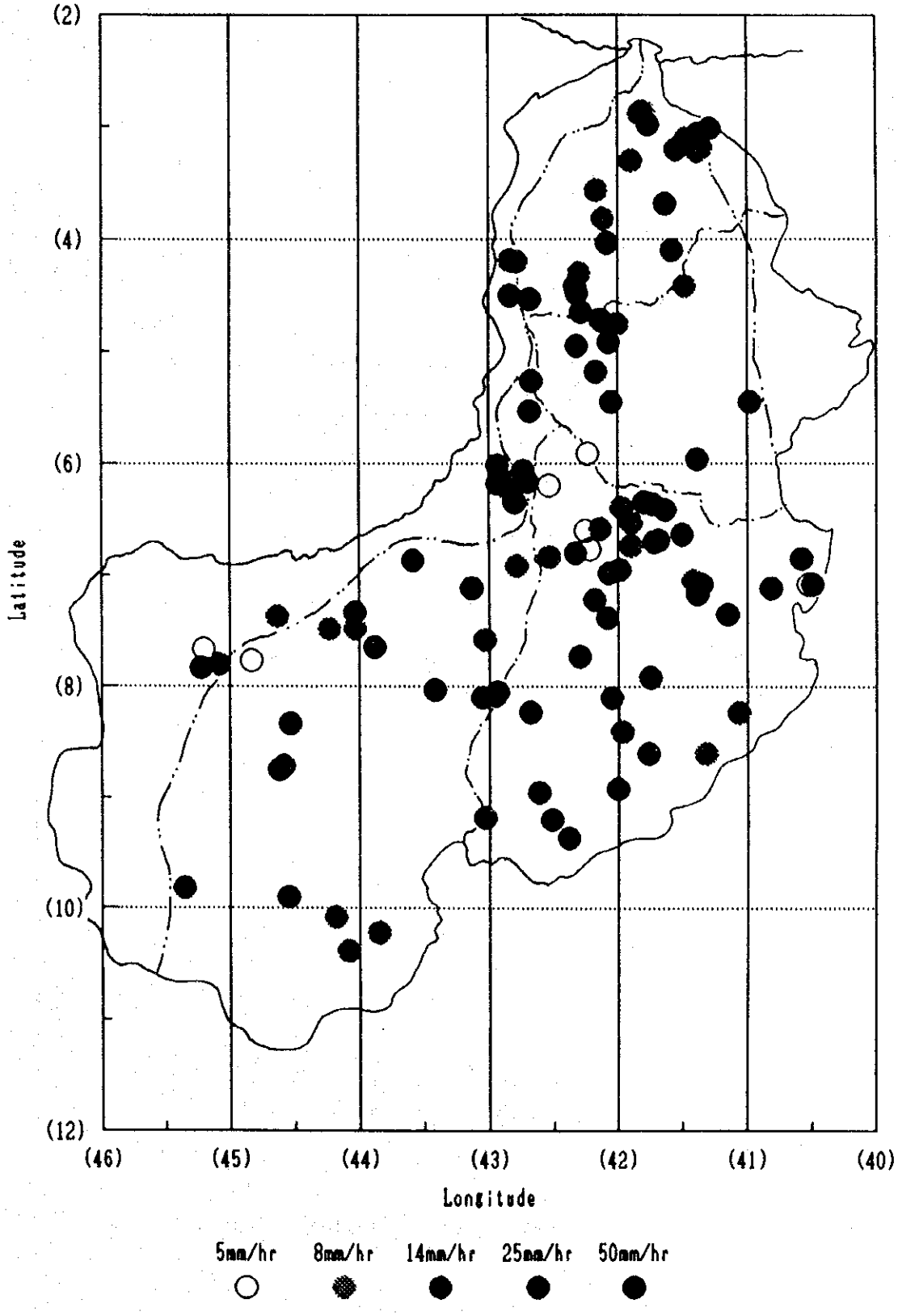

Fig. 8.14 Population (1550-1980) x1000per

(Grand Region)

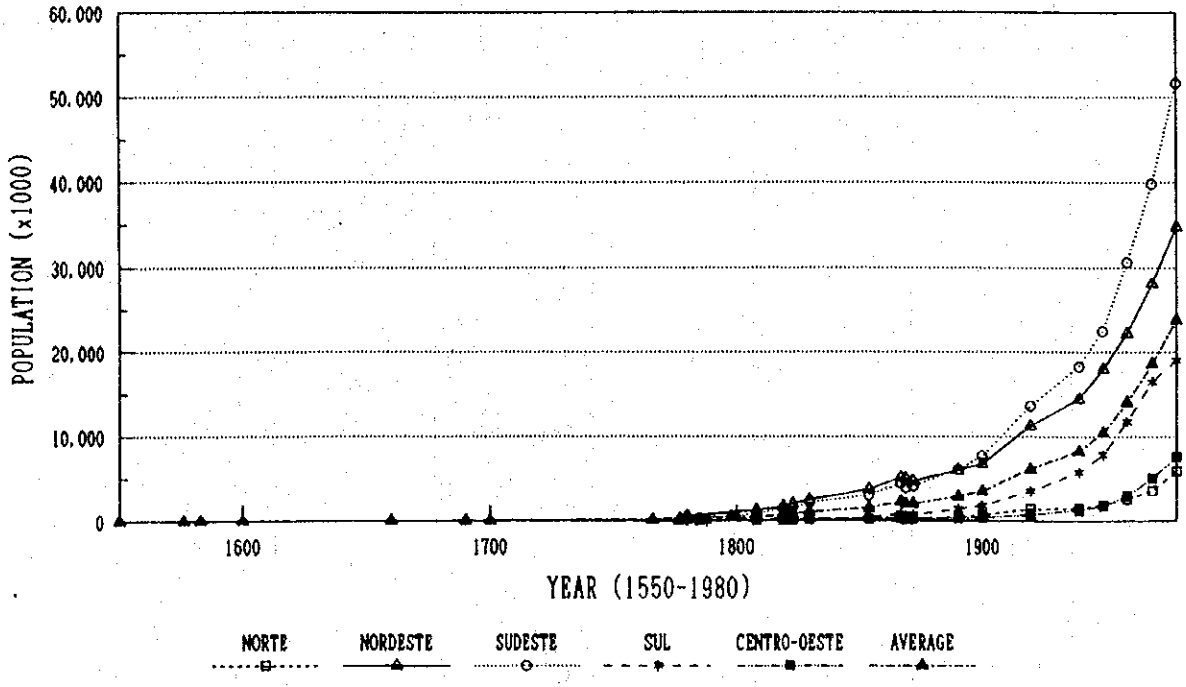

Fig. 8.15 Population of Nordeste Province x1000per

(1777-1980)